THE FARMER'S

PRACTICAL

HAND-BOOK

OF

AGRICULTURAL CHEMISTRY.

COMPILED BY

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CHEMIST ETIWAN WORKS.

CHARLESTON, S. C.

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TO THE FARMERS OF THE SOUTH.

An effort has been made to place in your hands a pamphlet containing useful knowledge. No originality is claimed as we have been largely indebted for our facts and figures to several notable works on agricultural chemistry. In some instances the text has been copied, and in others re-written. Among those books chiefly used, are American Manures, and Johnson, Sibson and Morfit's publications.

It has been written for the use of the customers of the Etiwan Company, and is intended to convey to them practical hints as to the use of our Fertilizers.

I am indebted to a farmer friend for the introductory chapter, and for the article prescribing the proportion of composted fertilizers to be used on different grades of land.

It is hoped that you will, in the course of this year, supply us with practical information, so as to enable us to revise and republish an improved edition next year.

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Chemist Etiwan Works.

CHAPTER I.

INTRODUCTION.

The use of commercial fertilizers has become a necessity of our age and situation.

There are those who cavil, and say the sale of guanos will ruin the country. The only answer we have to make is the fact that the average planter has sense enough to know, after the test of seven or eight years, that he makes annually a profit by the purchase, and use of the same.

That the annual sale of such manures increases and will increase; that England and Belgium both use more commercial fertilizers than the entire United States, though the area of the two countries combined is less than one-sixtieth the area of the United States.

The abuse of commercial fertilizers is to be regretted, and is a source of loss to the careless and slovenly farmer.

Among the abuses we may reckon:

1st. The application of a good fertilizer to improperly cleared, or wet and undrained lands, or to lands destitute of vegetable matter, neither of which can make a proper return, or the careless and improper cultivation of any lands of any grade on which such fertilizers are used.

2nd. The purchase of spurious and worthless articles, simply because they are considered cheap, and are sold on accommodating terms.

That class who improperly use and always abuse the sale of fertilizers are always subject to imposition by designing manipulators. They lay themselves open and fall a ready prey to the designing seller.

This pamphlet is gotten up for the use of, and addressed to the planters of cotton, tobacco, and those crops raised south of the Potomac, and east of the Mississippi River. If the intelligent planter in that section will for a moment consider, he will see that the Charleston Basin is his natural source of supply so far as bone phosphate of lime is concerned, nor can he see any sensible reason why these crude phosphates should be shipped to Boston, or any other point North, to be worked up, and in some cases adulterated, and returned to him for use, whilst the competition between our own manipulators is so great that he can reasonably expect the price to be low enough for no unreasonable profits to be left in the hands of the manufacturers.

A hue and cry comes from all corners of the land to raise money and build cotton factories. Every cotton planter longs to see the day in which every pound of cotton he produces will be spun into yarn or woven into cloth by machinery driven by the neighboring streams. He tells the capitalist that these factories pay twenty to thirty per cent. net profit. The Charleston manipulators of fertilizers have not pocketed the one-half of that net profit from the commencement of the work until today. Yet the farmers, who have money, would never dream of exacting less than eighteen per cent. from one another for its use, and it is the experience of the writer, himself a farmer, that cotton lands pay better dividends either directly or in enhanced value, than phosphate stocks, and these stocks are ever on the market, and heretofore generally under par; and why have not the farmers, who are capitalists, bought them up? The truth is the men who invested money in these manufactories were men who have other interests in and around the City of Charleston, and it was more with the hope of improving and enhancing the values of such other properties that these investments were made, than with a view of making extraordinary profits on the investments made.

The facilities for manufacturing superphosphates are as good or better in this city than they are at any other point on this continent.

The immense supply of bone, the character and area of which beds are hereafter described, afford an inexhaustible supply of bone-phosphate of lime. The superphosphate made from it is the principal base of all complete fertilizers, and, used alone, or in combination with domestic supplies of ammonia and potash, will supply all the wants of the farmer, so far as a commercial fertilizer is needed. The Etiwan Company has for several years shipped to the consumers, at $35 per ton on board the cars, a twenty-four per cent. soluble bone phosphate of lime, which would yield eleven per cent. soluble phosphoric acid, and about forty-five per cent. sulphate of lime, or land plaster. If we reckon the value of this compound as based solely on the amount of soluble phosphoric acid, it would cost sixteen cents per pound. But if the farmer will agree that sulphate of lime, or land plaster, is worth $10 per ton, or one-half cent per pound, it would give as the value of the land plaster in a ton of twenty-four per cent. dissolved bone, $4.50, which would reduce the price of phosphoric acid to fourteen cents per pound; and if you reckon the value of the small amount of insoluble bone phosphate of lime contained in it as of any value, even to less than that amount. The same company has also shipped a twenty-nine per cent. soluble bone phosphate at $38, which, basing its value solely on phosphoric acid, would give it at fourteen cents per pound, or, taking off one-half cent per pound for the sulphate lime contained, would reduce the value of phosphoric acid to twelve and one-third cents per pound, or, giving any value to the insoluble bone phosphate of lime, to even less than that price.

If articles of this character are purchased for cash they are cheap. If the farmer will purchase on credit he must pay for it as he does for other articles purchased in the same way. How many of them give $1.65 to $2 per bushel for corn on credit—about fifty per cent. over the cash value, and yet, with *hat* in hand, thank the merchant that is *so kind as to credit them with it.*

The writer of this article constantly hears the hue and cry, that the country is ruined. The farmers are all bankrupt, &c. He contends that such is not the case. The terrible results of our late revolution, the sudden emancipation of our slaves, and the upheaval and other confusion consequent upon the same, produced great confusion and much trouble, and in many cases utter bankruptcy. Even in this terrible state the farmer and planter has stood firm, and defying all difficulties and annoyances, and made his bread. fed and clothed his wife and children, aptly demonstrating the fact that the handfull of men who struggled against the combined world for liberty and self-government for the long period of five years, are, and will be, no ordinary race of men.

It was much to be regretted that immediately after the close of the war, the free negro labor of the country was so disagreeable to work with, that our most active-minded and energetic men rushed at once to other lines of business, when such offered, thinking it either impossible to make a living farming or too unpleasant a way of living. Yet many, who *were* unwilling, and some from choice, tied to the plow handles, have succeeded, and when we remember that we were *en masse* insolvent in April, 1865, and our country desolated by war, we may look around with astonishment and see many of our number "comfortably to do" in the world, well off, and many the base and under-pinning of solid wealth in hand.

The energetic planter of to-day is, in a measure, educated to the new order of things, and he has been through the chaos and confusion resulting from our conquered situation. Armed with ten years' experience, he will succeed, and there are those now living who will accumulate boundless wealth dug from the soil.

Our downfall was so sudden, the ills we were called on to bear so many, that it is not to be wondered at that we have almost become a race of grumblers and croakers. The farmers may now cheer up; a brighter day is rapidly dawning, and, with a profound state of peace for twenty years, the Southern staple crops of cotton, rice, sugar, and tobacco, will generate boundless and untold wealth. In 1865 and 1866, our staple crops were planted and worked with capital borrowed, at 2½ per cent. per month, by parties north of Mason and Dixon's line. Now they are made by either the planter's own capital, or by that advanced to him by the Southern factors or merchants. The South has *accumulated capital enough in ten years to plant and cultivate its own staple crops.* As soon as the farmer can accumulate capital enough within himself to pay cash for his labor, daily, weekly, or monthly, he can manage and manipulate the "hewers of wood and drawers of water," his employees; and the men who have prospered, we may say, belong exclusively to the Anglo-Saxon race, *who* must and will control the real estate and money of this country in all time to come.

If our croakers will look North they will find "all is not gold that glitters," and that our conquerors and wealthy neighbors have skeletons that dwell daily in their households. The terrible struggle, the endless strife, and strikes that are daily taking place between capital and its enchained slaves—men of the same race—the soup-houses of Northern cities, the statistics of crime—all show plainly that the mighty North has its own innate ills, most of which, thank God, we are free from.

Your first accumulated capital is invested in lands, buildings, and improvements; second, stock and tools to work the same; third, an investment in provisions and feed for one season; fourth, capital in cash to pay for all needful supplies purchased before you realize from the sale of crops, and wherewith to pay your wages to laborers;* and with this much in hand, with industry and energy, you must and will succeed; if you follow the farm for life, it will feed you and make you independent.

One source of accumulated wealth is in the permanent improvement of land. The improved annual production is absolutely necessary with hired labor to leave you margins for profits. Both the annual increase of crops and permanent improvement of lands may be made by the judicial use of commercial fertilizers. Yet, as a general thing, your capitals are so limited that you must purchase so that every dollar invested will produce the greatest possible return in the shortest possible time. To do this you must always buy the most highly soluble manures, and those are cheapest to you in the most

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* The capital now required to operate a plantation is, first, that invested in land; second, the amount of money in shape of cash in hand equal to the interest on the value of the slave property that formerly operated the same plantation, and that interest may be put down at three to five per cent.

Suppose, before the war, a plantation of five hundred acres had on it thirty slaves, six mules, etc. Averaging the slaves at $600 we will have $18,000; seven per cent, interest on this $1,260, at five per cent., $900, which is ample to run a five hundred acre cotton place, operated with six mules. Hence the farmer of to-day requires only the interest at five per cent. as cash in hand to operate a plantation on which he once used the entire principal. The man of the olden time replies, but the increase of the negro property. We of the new school reply, but the loss by death; rate the clothing and doctor's bills, the feeding of young negroes, dead-heads, superannuated, etc. Now you feed one ration for one day's work. The young negro raising and the old dead-head falls on the laborer, and he will find it will consume his as it once did all of your profits.

concentrated form, as a ton of dirt costs as much freight as the richest ton of fertilizer.

Your means of judging these are by actual test, and by analyses of parties in whom you can place confidence, and the nearer these parties are to your own home the better the security.

To enable you to understand the uses and values of commercial fertilizers, some knowledge of chemistry is absolutely necessary. The education of not one in one hundred farmers is such as to enable him to read and understand a standard scientific work couched in technical language. The object of this pamphlet is to supply the farmer with an abridged treatise on Agricultural Chemistry, written in English, without the use of technical terms as far as the use of the same can be avoided, and it is hoped it may serve a good end.

Much money is spent in printer's ink to publish clap-trap advertisements to aid in the sale of fertilizers. This Company prefers to print for the benefit of its customers a pamphlet containing solid information, which, having been copyrighted, can be reprinted from year to year and revised if the farmers appreciate the same, and we trust it may be in some part, as it were, "A Poor Richard's Almanac," and known as such.

Some articles following will enable you to comprehend the nature of the manufacture of commercial fertilizers and the uses of the same.

A knowledge of the various soils and properties of the same; the chemistry of plants; the application of commercial fertilizers; the value of domestic manures; the compost pile and sources from which it may be made up to profit and advantage; together with certain tabulated analyses of soils, plants, and fertilizers.

Charleston, S. C., October, 1875.

CHAPTER II.

GROWTH OF PLANTS AND MOLES OF IMPROVING.

In discussing the subject of Agricultural Chemistry we will consider the three systems under which the growth of plants may be classified.

1st. The natural, or normal system.

2d. The system whereby the natural or normal yield is maintained.

3d. The system called "high-farming," whereby it is sought to double or even treble the natural yield.

In all these systems certain conditions, such as soil, moisture, air, heat, light, electricity, must be constant; any great excess or deficiency in these *physical* conditions rendering plant life impossible.

Soils are the result of the disintegration of rocks, and are, therefore, as variable in chemical composition as are the rocks from which they are derived. The way in which the disintegration is accomplished is this:

No rock, however compact, is impervious to water. Water, as rain, therefore, holding in solution carbonic acid and oxygen, coming in contact with a rock penetrates it, and yielding up these gases to the elements for which they have an affinity, renders them soluble in the water; thus the rock breaks up from having some of its particles continually removed, so that if we should suppose a block of granite to be exposed to these conditions for an indefinite time, we would have it at first solid, then gradually disintegrated, next the mica and feldspar, pulverulent and fine, while the quartz remains massive, and lastly, all in solution but the clay and sand.

There is a property of soils which is of great importance in agriculture, and without which plant life would be difficult. This is the "absorptive power;" by this the soil absorbs and stores in itself nutritious substances both from aqueous solutions and from the atmosphere; and more, it even effects decomposition, so as to retain the useful and eliminate the useless material.

Thus if we apply to a soil a soluble chloride or sulphate, as potassic chloride or sulphate, a decomposition will take place; for if we pour on water we will find that the hydrochloric or sulphuric acid will leach out combined with lime, while the potash will be retained.

In general the soil absorbs the base and sets the acid free. Phosphoric acid is, however, a striking exception, for this acid is absorbed by soils in preference to most bases, and if in the compound both acid and base were necessary to vegetation, as in phosphate of potash, we would find that the soil absorbed them both in proportion to their degree of necessity.

On the atmosphere, the absorptive power of the soil is also freely exerted, taking therefrom air, carbonic acid, ammonia, water.

These physical conditions of plant-life being present, let us consider now the normal or natural system of plant growth.

If we take a plant and burn it we find that the greater portion is dissipated in the atmosphere, and there remains an ash, which we find, by analysis, to contain some of the elements which compose the surface of our earth. If we continue our experiment, we will find that though the relative amounts of these various ash-constituents vary in different plants, and even in different organs of the same plant, yet the greater portion of them are invariably present. If we now plant seed in a soil so prepared that these ash constituents are absent, the plant will not grow ; they are, therefore, necessary for the growth of the plant and must exist in the soil in such a condition as to be capable of assimilation.

This is accomplished, as we have seen, by the atmospheric (meteorological) phenomena which gradually decompose the silicates and other insoluble salts existing in the soil, and sets free these ash-constituents in a state capable of being dissolved by water and absorbed by the plant.

These ash constituents, therefore, form one important part of the food necessary for plants and must be supplied by the soil; they have, therefore, been called "ash-food."

The other portion of the plant which was dissipated by burning, we find by analysis to be composed of carbon, hydrogen, oxygen, and nitrogen. These are equally important and essential, and, as the atmosphere is their source, we call them "air-food."

The carbonic acid of the atmosphere is under the influence of light decomposed by the leaves of plants, the carbon being assimilated, while the oxygen is returned for the use of animals. Plants are in fact the world's scavengers, and render the earth inhabitable by animals. Animals breathe in oxygen from the atmosphere and exhale carbonic acid. This gas is poisonous and if suffered to accumulate in the atmosphere, would soon cause the death of all warm blooded animals ; but the plants seize it, and, taking what is necessary for themselves, return the pure oxygen for the use of the animals.

If we turn to Geology we see this beautifully exemplified. At one period the atmosphere, from igneous and other causes, was reeking with moisture, and so filled with carbonic acid that animal life, with the exception of some of the lower orders of cold blooded reptiles, was impossible. During this period, called the carboniferous period, plant life flourished most luxuriantly, and the gigantic conifers and other growths of that day cleansed the atmosphere and rendered higher life possible by decomposing the deleterious carbonic acid, returning the life-bearing oxygen, and storing the carbon for man's future use in the vast coal measures of the world.

Nitrogen also, in this normal condition of vegetation, is supplied by the atmosphere, and is always taken up in the form of ammonia, which exists in the air, and is generally collected by rain and dew, which also furnish the remaining elements of plant food, viz: oxygen and hydrogen.

Now all these substances which constitute the plant food, both those supplied by the soil, and those supplied by the atmosphere, must not only be present, but present in the relative quantity required by the plant for it to grow; no one of them can can be absent or even present in too small quantity without the plant failing to grow and mature; hence, normal vegetation depends upon the available amount of that constituent of the plant food which is present in least quantity.

In addition to these elements of plant food, there must be a matrix in which the food is, and which may at times supply some of the elements of the food, sustaining it also in its proper position, and protecting it from vicissitudes of climate. This is the vegetable mould or humus mixed with clay and sand.

Let us now review the normal or natural system of vegetation in its totality. A tree springs up, assimulates all its ash-food from the soil, and all its air-food from the atmosphere; it arrives at maturity and dies; as soon as dead, decay, which is the same thing as slow combustion, sets in, and our analysis proceeds; all the materials which were derived from the atmosphere being returned to it, except humus, while the soil receives the ash-food back again.

In this system the exhaustion of ash-food from the soil is not possible: on the contrary, by the action of the atmosphere on the soil more ash-food is rendered available, so that the amount is constantly increasing.

The second system, whereby the natural yield is maintained, presents some very different characteristics.

This system only obtains where the produce of the soil is used for the wants of man and animals. Here there is something carried away, so that the materials of the soil are constantly decreasing; thus, in a wheat crop, making fifteen bushels per acre, there is carried off annually from the soil by the grain eight lbs. of phosphoric acid and seven lbs. of potash; and should the straw be also exported, there will be an additional drain of six pounds phosphoric acid and ten lbs. potash. Total, 14 and 18 pounds.

This excessive loss of mineral material, if recurring yearly, can by no means be restored by the slow method of atmospheric action, so that under such a system it is certain the crop will continually diminish in quantity and quality, until at last the land will cease to produce.

As this result becomes manifest by experience, remedies are sought, and the system of "bare" fallowing was adopted; for by allowing the land to remain idle for one or two years after one or two crops have been gathered, the materials abstracted by the plant are in some measure returned by atmospheric action.

As this system required a large amount of land prepared for culture, it was not found very profitable, and has been very generally abandoned; in its place "rotation" has succeeded.

The principle of rotation rests upon the fact that different plants take from the soil different quantities of its mineral constituents, so that though a soil deficient in some constituent will not grow a plant which requires much of that material, still it will grow and mature other plants, which either do not use that constituent, or use it in less quantity.

In "rotation" we grow plants whose demand for some of the materials of the soil is less than were the preceding, so that by the time the rotation is completed, the materials required for the first crop have been restored by atmospheric action.

In the third system, or the system of "high-farming," it is sought to raise the greatest amount of fruit per acre, and consequently to carry off from the soil the greatest amount of available substances which form the seed.

The increase of the *weed* of the plant is of no importance, hence it will be seen that a morbid growth is demanded, that is, a greater amount of seed should be yielded than is normally proportioned to the weed.

In this system, therefore, the plant must be furnished not only with a greater amount of ash and air-food than is normally present, but they must also be so proportioned as to produce this morbid growth of fruit. This is done by manuring; we must stimulate the plant to assimilate those materials which compose the fruit, and those materials must be supplied in an easily available state, and in an abundant quantity; if, therefore, we apply to the soil a compound of air and of ash-food in just proportions, and in an easily available (that is, highly soluble) state, all the conditions of "high-farming" are fulfilled.

It is evident that we cannot increase the atmosphere, but we can add it to the soil, either by growing certain crops, as peas and clover, which absorb large quantities of air food from the atmosphere, and then plough them in; or, more quickly, we can at once apply to the soil nitrogenous compounds, as the nitrates, ammoniacal salts, etc. The system, then, of "high-farming" demands an application yearly to the soil of a mixture or manure composed of the ash-food of the plant, and especially of the seed in a soluble state, together with some nitrogenous compound. The highly concentrated fertilizers of commerce only in part meet this requisition, as they only contain the most necessary ingredients of plant food, and many of the physical uses of farm manure would be lost if they were used alone, such as heat, humus, porosity.

CHAPTER III.

THE SOIL.

ORIGIN OF SOILS.

The greater part of the surface of the land is covered by a mixture of stones of various sizes, clay, sand, and other mineral substances, together with a variable quantity of decaying vegetable matter—this is the soil. In some places it exists only in patches and thin layers on the surface of rocks, and affords only a scant growth of mosses, lichens, etc., while elsewhere it will be found as a deep mass of vegetable mould, so fertile that the crudest cultivation will produce heavy crops of all the crops necessary for man and animals. Between these extremes are found all the varieties with which we are familiar.

Soils are classified agriculturally, according to their composition and texture, into *sandy*, containing only ten per cent. clay, *sandy loam*, containing 30–40 p. c. clay *loam* containing 40–70 p. c. of clay. When it contains 70–85 p. c. of clay, it is called a *clay loam;* from 85–90 of clay a *strony clay*, fit for bricks, and if it contains no sand, it is called *pipe clay*. If a soil contains more than five per cent. of lime it is called a *marley soil;* if more than twenty per cent. a *calcareous soil*, and if the soil consists almost entirely of vegetable matter, it is called a *peaty soil* or *bog earth*.

Geologically, soils are divided into two kinds, *soils of disintegration and soils of transport*. The former are found lying on the rocks from which they were formed by the mechanical and chemical action of the atmosphere, and having the same compositions as the rocks ; while the latter have been transported by the agency of winds, waters, or glacial action, to a distance from their source, and are found on rocks having a far different composition from the overlying soils.

All soils originate in the disintegration of rocks which form the surface of the earth, chiefly by the action of the atmosphere. This action, as we have said, is of two kinds, *mechanical* and *chemical*. The mechanical action consists in the power exerted by volcanoes, floods, ice, and snow; also the abrading action of winds, which by forcing small particles of sand against the surface of rocks, wears them away as with a file. The chemical action is exerted by the elements of the atmosphere, combining with certain ingredients of the rocks. Thus those rocks which contain lime and alkalies, are acted upon by the carbonic acid of the atmosphere. Those containing iron by the oxygen. These actions of the atmosphere are also assisted by the root-growth of plants, by the burrowing of worms and other underground creatures, and also in no small degree by the acids (humic, geic, crenic,) generated by the decay of organic substances.

The rocks essential to the formation of fertile soils, and from which they are usually formed, are Granite, Feldspar, Limestone, Gypsum, Phosphorite, Slate and Sandstone.

Granite derives its name from its granular structure, and is composed of a mixture of grains of Mica, Feldspar, and Quartz.

Quartz forms the transparent grains, and is composed simply of silica.

Feldspar, the dull creamy opaque grains, is composed of silica, alumina, potash, soda, and lime.

Mica, so called, from its forming the glittering scales, is a compound of silica, alumina, and potash; in some varieties the alumina is replaced by iron, and the potash by magnesia.

Limestone is a compound of lime and carbonic acid, and is formed of the remains of shell fish and coral insects. The lime of the soil is derived from limestone, gypsum and phosphate of lime. Gypsum is a compound of lime and sulphuric acid, and is found in some places in vast beds, while the phosphate of lime (phosphorite) is more rare. In Canada and Northern New York it occurs in the ancient unstratified rocks as the apatites; in South Carolina also it is found in the recently discovered phosphate beds, which are, perhaps, the largest and most available sources of phosphoric acid in the world.

The country is indebted to Dr. N. A. Pratt, of Chaleston, for discovering the value, and aiding in the development of this great source of national wealth. He says, in his report on this subject: "This bed has long been known in the history of the geology of South Carolina, as the "Fish bed of the Charleston Basin," on account of the abundant remains of marine animals found in it—Professor Holmes, of Charleston, having not less than 60,000 sharks' teeth alone, some of them of enormous size, weighing from two to two and a half pounds each. The bed outcrops on the banks of the Ashley, Cooper, Stono, Edisto, Ashepoo, and Combahee rivers; but is developed most richly and heavily on the former, and has been found inland forty or fifty miles. Near the Ashley river, it paves the public highways for miles; it seriously impedes and obstructs the cultivation of the land, affording scarcely soil enough to hill up the cotton rows; and the phosphates have for years past been thrown into piles on the lawns and into the causeways over ravines, to get them out of the reach of the plows. It underlies many square miles of surface continuously, at a depth ranging from six inches to twelve or more feet, and in such quantities, that from five hundred to a thousand tons underlie each acre. In fact, it seems there are no rocks in this section which are not phosphates.

"The area of this bed, containing phosphates of good quality and in workable quantity, so far as known and examined by the writer in person, is not less than forty to fifty square miles, though from samples I have examined from beyond these limits, I am led to believe that the rock will be found of good or indifferent quality, and in greater or less quantity, over an area of several hundred square miles. When of inferior quality, they contain more sand, carbonate of lime, oxide of iron, and phosphate of iron and alumina, and proportionately less pure phosphate of lime."

As the amount of this material is so large, it will doubtless be the chief source of supply for many years to come, and there will probably be little variation in its price; and as there are no drawbacks or checks to the mining and economical transportation of it to all parts of the Atlantic coast, we will estimate the value of insoluble phosphoric acid from it. We give the following tables from Dr. Pratt's interesting pamphlet on the "History of the Discovery and Development of the Native Bone Phosphates of the Charleston Basin," giving analyses of different samples of this guano, and of some other leading commercial guanos, for comparison.

		Phosphate of Lime.	*Phos. of Iron and Alumina.*	*Carb. Lime and Magnesia.*	*Organic Matter*	*Sand*
South Carolina,	No. 1	34.40				29 32
"	" 2	55 52	1.50	10.33	6.50	10 31
"	" 3	63.30	1.32	8.20		9.01
"	" 4	68.03	5.02	8.03	7.50	9.91
"	" 5	66.36	3.01			11.70
"	" 6	61.93	1.04	11.21		
"	" 7	64.07	.84	11 00		
"	" 8	69.00				
"	" 9	59.07	.65	5.68		
"	" 10	49.35	1.84	25.70		
"	" 11	49.87	.86	4.73		
"	" 12	50.07	.69	10.14		
Navassa Guano,		49.12	12.00			
Swan Island Guano, mean of two analyses,		53.08	12.33		20.60	15.40
Bolivian,		53.20	9.23		18.24	4.08
Patagonian,		44.00	Phos. Iron and Alum'a combined.		18.30	35.60
Chilian,		31.00			18.60	43.17

Sand stones are composed of alumina, silica, iron, carbonate of lime, and other substances in various proportions. In some the particles are cemented together by a kind of semi-fusion, as in the buhr-stone formation, while in others, as the free stones and red sand stones, it is effected by the infiltration of some soluble substance. They are easily disintegrated and rapidly form soils.

An important constituent of all soils is the vegetable mould, or *humus*, which must be at least five per cent. of the soil, if it be a fertile one. This *humus* is the brown, earthy part of the soil, and is the result of the partial decay of leaves, roots and all other parts of plants. The special office of this constituent is mechanical, and it acts by absorbing heat, moisture, and fertilizing gases from the atmosphere, and storing them for the growing plant; it also affords support to its structure. That the fertility of a soil does not depend directly upon the percentage of humus has been proven, but up to a certain point it must be present to make a fertile soil.

In order that the planter may form an idea of different soils, we here give several analyses of various ones:

(1.)	*A Fertile Vegetable Mould.*	*A Good Sandy Soil.*	*A Fertile Clay Soil.*	*A Fertile Loamy Soil.*	*A Calcareous or Lime Soil.*	*A Marly Soil.*
Organic Matter, Humus, &c.	10.08	.49	3.38	11.24	6.33	10.50
Oxide of Iron	6.30	3.19	8.82	4.87	9.31 (Oxide of Iron and Alumina)	11.92 (Oxide of Iron and Alumina)
Alumina	9.30	2.65	6.67	14.04		
Lime	1.01	.24	1.44	.83	cost of lime 54.56	19.92
Magnesia	.20	.70	.92	1.02	trace	.25
Potash	.01 (Potash and Soda)	.12	1.48	2.80	1.03 (Potash and Soda)	.71 (Potash and Soda)
Soda		.02	1.08	1.43		
Phosphoric Acid	.13	.07	1.51	.24	trace	.38
Sulphuric Acid	.17	trace	trace	.09	trace	.04
Chlorine	....	trace	....	.25	....	.76
Insoluble Silicates, (Clay and Sand)	72.80	92.52 sand	72.83	63.19	28.77	55.52
Carbonic Acid and Loss	....	....	1.87	....	....	....
	100.00	100.00	100.00	100.00	100.00	100.00

(2.) Analysis of a very fertile soil, near the Zuyder Zee, Holland (Mulder):

		Tons per acre 10 in. deep.
Insoluble silica (sand) and alumina.		
Soluble silica	57.646	576.0
Soluble alumina	2.340	23.0
Peroxide of iron (iron rust)	9.039	90.0
Protoxide of iron	0.350	3.5
Lime	4.093	40.0
Magnesia	0.130	1.3
Potash	1.026	10.0
Soda	1.972	19.0
Chlorine	1.240	12.4
Ammonia	0.060	1200 lbs.
Phosphoric acid	0.466	4.5
Sulphuric acid	0.896	9.0
Carbonic acid	6.085	61.0
Humus and water chemically combined	12.000	120.0
Loss	0.828	
	100.000	

(3.) Analysis of a remarkably sterile soil:

		Tons per acre 10 in. deep.
Sand	95.843	958.00
Alumina	0.600	6.00
Oxide of iron	1.800	18.00
Lime combined with silica	0.038	0.38
Magnesia	0.006	0.06
Potash and soda	0.005	0.05
Phosphate of iron	0.198	1.98
Sulphuric acid	0.002	0.02
Chlorine	0.006	0.06
Humus, carbonic acid and water	1.502	15.02
	100.000	

The poverty of this soil is apparent from the small amounts of lime, potash and phosphoric acid present. The addition of marl was found to produce a decided effect.

A rough way by which the planter may determine whether his soil has sufficient lime is to take a small quantity, put it in a wine glass, and pour some muriatic acid over it. If the earth bubbles up, or if, on putting the glass to the ear, a fizzing is heard, there is enough lime; if no disturbance occurs, lime is probably needed.

DESCRIPTION OF THE ORGANIC SUBSTANCES OF THE SOIL.

The names of these in the order in which they occur in relative abundance in an average fertile soil, are

Silica (sand), Alumina, Oxide of Iron, Lime, Magnesia, Potash, Soda, Sulphur, Phosphorus, Chlorine, Fluorine.

Silica is a compound of 53.34 per cent. of oxygen, and 46.66 per cent. of a metal called silicon. This metal never occurs in nature, but was discovered by Sir Humphrey Davy, in 1813, and is obtained as a brown powder or as scaly crystals, like graphite. Silica has acid properties, that is it combines with alkalies, and exists in three forms, crystalline, amorphous, and jelliform; when crystalized it forms hexagonal (six-sided) transparent, colorless prisms, which are called rock crystal; when amorphous, it is white, gritty and tasteless, as in flint and sand. Neither of these forms when pure are acted on by any of the acids except the hydrofluoric, nor even by the strongest fires.

The jelliform variety is called soluble silica, and is a combination of silica and water, which is slightly soluble in water and freely so in acids, even carbonic. This is the immediate source of the silica in plants, and it is formed from the akaline silicates of the soil; thus, if we have a powder composed of silica, lime, potash, etc., such as powdered feldspar, and expose it to the action of water containing carbonic acid, as rain water, the latter will unite with the lime, potash, etc., and leave the silica in the soluble form, when it is readily appropriated by the plants.

From the want of enough of this in the soil, those plants that need it largely in their straw, as wheat, oats, rye, etc., are unable to stand up, and fall down and rot.

As the amount of soluble silica in soils is small, all the straw of the crops, and all the weeds that grow in swampy places, or running water, should be returned to the soil best through the compost pile.

Alumina.—This substance, which is a compound of the metal aluminum and oxygen, exists in nature in two forms, crystalline and amorphous; when crystallized, it forms the precious stones, as the ruby and the sapphire; when amorphous, it is very like silica, white, gritty, hard. In the soil, however, it usually occurs as *clay*, which is a compound of silica and alumina. This substance does not form plant food, for it is seldom absorbed by the roots of plants, but its office is chiefly to absorb and retain moisture and all the soluble salts of fertilizing substances. When clay is present in large quantity the land must be drained, or it will be wet, cold, and heavy; if deficient, the land will be "hungry," and the fertilizing salts will be washed away from the roots of the plants. Instance the porus soils of the coast. A very important property also of clay is its power of absorbing ammonia from the atmosphere and conveying it to the roots of plants. The color of clay is caused by the presence of oxide of iron.

Oxide of Iron.—This substance occurs in two forms, as protoxide, consisting of a combination of one equivalent of iron and one of oxygen, and peroxide or sesquioxide, which consists of two equivalents of iron to three of oxygen. The former is of a dark color, constituting largely the scales on the anvil of the smith, and exists in the blue clay lands. The latter is familiar as iron rust, and causes the red color of most clays. Lands which contain the protoxide should be frequently cultivated, so as to expose this oxide to the atmosphere so that it can absorb oxygen and be converted into the harmless red oxide. During this oxidation, hydrogen is set free, which then combines with nitrogen to form ammonia, and as the red oxide has slightly acid properties, it fixes the ammonia for plant food. Soils which contain iron pyrites will have formed in them this protoxide, in the form of sulphate or copperas. The presence of this salt, in more than very small quantity, is poisonous to plant life; if, however, it be well cultivated, or still better, if it be limed, the injurious protoxide will, after a time, be converted into the harmless red oxide. The use of iron in plants seems to be in the formation of the green coloring matter in them.

Lime.—This, one of the most important constituents of soils and also one that is very widely disseminated, is derived from the limestones, which are found in nearly every geological period, and also from gypsum, or land plaster, which in some places occurs in large beds. Limestone is a combination of lime and carbonic acid gas. When this is burnt in kilns, the carbonic acid gas goes off, and a hard, white, caustic substance remains. This is stone lime, or quick lime. If now water is poured on, (one part of water to three of lime,) it grows very hot, swells up and finally falls into an impalpable powder, called slacked lime. If it continue to be exposed to the air, it again absorbs carbonic acid and becomes reconverted into limestone; but it is in very fine powder, and not hard and massive as was the original rock. In this fine state it is readily absorbed and assimilated by plants.

Gypsum is a combination of lime, sulphuric acid, and water. When this is burnt, the water is driven off, and it is called plaster of Paris. In this state it reabsorbs water with great avidity, and sets or becomes hard, thus making an excellent material for taking casts, &c. If, however, it is burnt at too high a temperature, it loses this property and is incapable of reabsorbing water.

Magnesia.—This substance resembles lime, and is generally found with it in combination with carbonic acid, as in dolomite, magnesian limestone, serpentine, etc.; it is also found combined with silica, a variety of which is familiar as meerschaum, from which pipes are made. There are also two other forms, the carbonate of magnesia, and the sulphate, which is called Epsom salts. Magnesia must be present for plants to have health, but in abundance often acts injuriously; combined with phosphoric acid, it forms a large proportion of the ash of the cereals, as wheat, barley, etc., and it occurs chiefly in the bran.

Potash.—When wood is burned, a greyish white ash is left: this is chiefly carbonate of potash; by strong firing this is converted into the potashes of the shops, which is a mixture of carbonate and caustic potash. This more purified, that is, containing less carbonate and more caustic, is called pearlash; and when pure, caustic potash, which is a combination of oxygen and the metal potassium. The "lye" from wood ashes is a solution of carbonate of potash, and is used largely in washing, as it softens hard water by precipitating the lime as carbonate, and the potash unites with all greasy matters to form soap. The potash of the soil is derived chiefly from feldspar, which contains sixteen per cent., and which, as we have stated, is a constituent of granite. Granite contains about one per cent. of pure potash.

Soda.—This substance resembles potash, and appears to take the place in marine plants that potash does in land plants; the ash of sea weed consisting chiefly of carbonate of soda. In soils it occurs chiefly as chloride of sodium or common salt, and is found only in small quantity.

Phosphorus.—This substance is a yellowish semi-transparent substance, soft as wax, and inflammable by the slightest friction; on burning, it combines with oxygen and forms phosphoric acid. In combination with lime and magnesia it is found in soils; and in the same combination it constitutes a large part of the bones of animals. When bones are burnt a fine white ash is left. This is the "bone ash" of commerce and consists of about eighty per cent. of phosphate of lime. If this ash is mixed with charcoal, and heated in a retort, the phosphorus distils over and is caught by drops in water. This, however, is a dangerous experiment. As this substance is found in such small quantity in soils, and in such large quantity in plants, it is the one soonest exhausted, and, therefore, has to be replaced by the superphosphate of commerce.

Sulphur, also called brimstone, is a hard, yellow, brittle substance, devoid of smell or taste. It is found around volcanoes mixed with earthy impurities: by melting the sulphur is freed from these, and imported for the purpose of making sulphuric acid. In the soil sulphur is generally found as sulphate of lime.

Chlorine and Fluorine. Little need be said of these substances. They occur in soils combined with soda and lime, the first as common salt or chloride of sodium, and the latter as fluor spar, or fluoride of calcium. This is absorbed by plants and is conveyed to animals chiefly to form the enamel of the teeth; it also exists in smaller quantity in the bones. Common salt occurs in large beds, known as rock salt: it is also found in the atmosphere near the sea, and also occasionally in the rain of places far interior, where it is supposed to have been carried by high winds.

CHAPTER IV.

PLANTS.

All plants are composed as we have said, of two parts; the organic and the mineral; the latter we have treated of in the preceding chapter, while the organic parts are those derived from the atmosphere, and are carbon, hydrogen, oxygen and nitrogen, and are built up into more complex forms by the vital force of the plant.

Some plants require more of one substance than others, and on this is based the principal of rotation as has been said.

Thus, there are the potash plants, as corn, beets, turnips and potatoes, whose ash contains more than half its weight of potash.

The lime plants, such as beans, peas, clover, tobacco, have their ash chiefly composed of lime and magnesia.

There are also the silica plants, such as wheat, rye, oats, barley.

In all these different ashes, of whatsoever class, phosphoric acid forms a large proportion, and is usually united with the predominant bases of the ash.

Now as these ingredients are necessary for the plants to grow and mature, they must be present in sufficient quantity, and in a readily available form; that is, there must be enough of them soluble in water.

These mineral constituents of plants form but a small proportion of the weight of the plant, from three to six per cent., and they were for a long time considered of no consequence, but experience has proved their absolute necessity for the growth of crops; and as surely as crops are continually grown and exported, so surely does the land diminish in productiveness, unless restored by artificial means. This is manuring.

To show how large is the quantity of these necessary substances which is removed, we transcribe several tables:

WHEAT.

Twenty-five bushels of wheat, at 60 lbs. to the bushel, the product of an acre, weighs 1,500 pounds; the straw of this grain will weigh 3,000 lbs. The wheat and straw removes from each acre of land the following weights of the elements:

	Grain.	Straw.	Total.
Ammonia	41.71 lbs.	10.18 lbs.	51.89 lbs.
Phosphoric Acid	15.00 "	11.10 "	26.10 "
Sulphuric Acid	1.08 "	5.10 "	6.90 "
Lime	1.35 "	12.00 "	13.35 "
Magnesia	4.65 "	5.10 "	9.75 "
Potash	12.00 "	23 70 "	35.70 "
Silica	1.05 "	143.10 "	144.15 "

The table shows also the relative amounts of the different elements required to raise wheat.

INDIAN CORN.

Fifty bushels of corn—the estimated crop of an acre—of 58 lbs. to the bushel = 2,900 lbs. This weight of corn will require 3,000 lbs. of stalk and cob (when dry), and will contain:

	Grain.	Stalk and Cob.	Total.
Ammonia	34.22 lbs.	6.06 lbs.	40.22 lbs.
Phosphoric Acid	25.81 "	13.50 "	39.31 "
Sulphuric Acid	2.90 "	8.40 "	11.30 "
Lime	.87 "	17.70 "	18.57 "
Magnesia	7.83 "	9.30 "	17.13 "
Potash	15.08 "	59.70 "	74.78 "
Silica	2.32 "	81.60 "	83.92 "

The reader will notice that Indiau corn requires much more phosphoric acid and potash than wheat, while the amount of ammonia is only a little more than half as much; consequently, its nutritive properties as food are in about the same proportion; that is, in proportion to the ammonia. Corn stalks contain a large amount of potash and silica, and, when properly prepared as manures, will furnish these elements for other crops. From the comparatively small amount of ammonia required by the corn crop, it can be raised at less cost to the soil than wheat, because ammonia is one of the most costly of the organic elements.

RYE.

Thirty bushels—estimated product of an acre--of 50 lbs. to the bushel = 1,500 lbs.; the same weight as 25 bushels of wheat. This crop requires at least 3,000 lbs. of straw. The grain and straw contain:

	Grain.	Straw.	Total.
Ammonia	34.05 lbs.	8.70 lbs.	42.75 lbs.
Phosphoric Acid	13.65 "	8.10 "	21.75 "
Sulphuric Acid	7.50 "	3.00 "	10.50 "
Lime	1.05 "	12.30 "	13.35 "
Magnesia	2.25 "	4.50 "	6.75 "
Potash	8.55 "	24.00 "	32.55 "
Silica	7.80 "	90.00 "	97.80 "

By comparing the above table with the one giving the composition of wheat, the reader can understand why larger *continuous* crops of rye than of wheat can be raised from the same soil; because rye does not require so much of those elements which are first exhausted in soils as wheat does. In like manner, by studying the composition of different crops, and noting the amounts of the different elements required to produce them, we can understand why farmers should have a dollar for a bushel of wheat, when corn is selling at fifty cents, and rye at seventy-five. Such an examination shows that the quantity, and consequently the price of any crop, are naturally regulated by the amount of certain valuable substances required for its production.

OATS.

Fifty bushels of oats—the estimated product of an acre—of 33 lbs. to the bushel=1,650 lbs. This amount of grain requires about 2,000 lbs. of straw. The grain and straw contain:

	Grain.	Straw.	Total.
Ammonia	37.45 lbs.	7.80 lbs.	45.25 lbs.
Phosphoric Acid	10.39 "	4.00 "	14.59 "
Sulphuric Acid	6.62 "	3.20 "	9.82 "
Lime	1.81 "	7.40 "	9.21 "
Magnesia	3.47 "	3.80 "	7.27 "
Potash	7.59 "	6.00 "	13.59 "
Silica	2.14 "	45.40 "	47.54 "

The reader will note the large amount of ammonia required by this crop. This accounts for the nutritive properties of the grain and straw. The amount of phosphoric acid and potash is small compared with that of other cereals.

BARLEY.

Thirty bushels of barley—the estimated product of an acre—of 48 lbs. to the bushel=1440 lbs. The straw weighs 2000 lbs. The grain and straw contain :

	Grain.	Straw.	Total.
Ammonia	33.40 lbs.	7 60 lbs.	41.00 lbs.
Phosphoric Acid	9.64 "	5 40 "	15.04 "
Sulphuric Acid	1.73 "	4.40 "	6.13 "
Lime	.72 "	8.80 "	9.52 "
Magnesia	2.44 "	2.80 "	5.24 "
Potash	6.33 "	25.80 "	32.13 "
Silica	7.63 "	68.80 "	76.43 "

Oat and barley straw are good manures, as they are rich sources of nitrogen, containing, as they do, a large percentage of ammonia. From this cause also, they make good fodder for cattle. Only a small amount of phosphoric acid and potash is required for these straws, while the amount of silica is only one half of that required for wheat straw.

POTATOES.

One hundred bushels of potatoes, of 60 lbs. to the bushel=6000 lbs. of tubers. The tops, when dry, weigh about 3000 lbs.; and the tops and tubers of such a crop contain :

	Tubers.	Tops.	Total.
Ammonia	21.00 lbs.	1.50 lbs.	22.50 lbs.
Phosphoric Acid	33.00 "	18.00 "	51.00 "
Sulphuric Acid	12.60 "	15.50 "	28.10 "
Lime	4.20 "	55.00 "	59.20 "
Magnesia	7.80 "	10.50 "	18.30 "
Potash	109.00 "	70.00 "	179.00 "
Silica	13.00 "	30.00 "	43.00 "

Twenty bushels of wheat require 15 lbs. of phosphoric acid for the grain, and 11 lbs. for the straw; while 100 bushels of potatoes require double this amount. Hence, two medium crops of wheat exhaust only as much of this valuable element as one crop of potatoes. Also, only one-sixth the amount of potash required for potatoes is necessary for the wheat crop. In raising potatoes, few farmers supply a sufficient amount of phosphoric acid and potash. Hence, this plant and its tubers have become constitutionally deteriorated on most farms, and liable to speedy decay. A bushel of potatoes contains only about one-seventh the amount of nitrogen contained in a bushel of wheat, and its nutritive value for the production of blood and muscle is in the same proportion.

CLOVER HAY.

Two tons, or 4,000 lbs., of dried clover may be considered an average crop per acre. This amount contains:

Ammonia	52 00 lbs.	Lime	75.00 lbs.
Phosphoric Acid	19.76 "	Magnesia	21.00 "
Sulphuric Acid	7.50 "	Potash	80.69 "
Silica	18.65 lbs.		

Clover requires a large amount of potash and ammonia, while the amount of silica required is small. Great benefits are realized by growing this crop; it sends its roots deep into the soil, and brings up the phosphate and sulphate of lime, also potash and magnesia; and when the clover is ploughed under, as a green manure, it furnishes a large amount of the nitrogen required for a heavy crop of wheat.

All root crops require a rich soil to do well. Twenty tons of turnips or carrots, with the tops—which is a large crop for an acre—require:

	Turnips.	Carrots.
Ammonia	42 00 lbs.	48.00 lbs.
Phosphoric Acid	45.00 "	39.00 "
Sulphuric Acid	50.00 "	57.00 "
Lime	90.00 "	197.00 "
Magnesia	14.00 "	29.00 "
Potash	140.00 "	134.00 "
Silica	55.00 "	60.00 "

Tobacco and cotton require a rich soil to grow luxuriantly, as the following table, showing the amounts, in pounds, of inorganic elements contained in 1,000 lbs. of the stems and leaf of tobacco, and the fibre, seed, and stalk of cotton, in their air-dried state, will show:

		Cotton.		
	Tobacco.	Fibre.	Seed.	Stalk.
Phsophoric Acid	8.6	8 3	14.8	5.5
Sulphuric Acid	9.3	5.6	1.6	0.5
Lime	88 8	25.7	2.4	7.0
Magnésia	25.0	14.5	5.6	2.2
Potash	73.7	54.0	14.4	8.8
Silica	23.0	1.3	3.4	2 5

We regret that we could not obtain reliable analyses of cotton and tobacco, showing the amount of nitrogen or ammonia required. The reader can see that in raising tobacco, a large amount of lime and potash is required, while the amount of phosphoric acid is small. The cotton plant requires more phosphoric acid, but either crop can be raised more readily and profitably from ordinary soils, where climate is suitable, than either wheat or corn.

The foregoing Tables are of great value to the farmer and planter, in showing them the amount of the different valuable elements required by different crops ; also, how far the commercial manures of a known composition are able to supply the material for these crops. If the reader wishes to know how much of those elements which are not usually applied as principal constituents of manures, such as oxygen, hydrogen, chlorine, iron, soda, and carbon, is required by plants, he may refer to the Tables on pages 28 and 29 which will show him the percentage of these substances; and from these he can readily calculate the amount required by different crops for an acre.

Every crop should be supplied with the full amount of all the substances needed to bring it to maturity. That this vital principle is not understood, or at least attended to, is painfully evident from an examination of the statistics furnished in the reports of the Agricultutal Department, at Washington. By these reports we find that the average of the amounts of the different crops raised on an acre in thirty States of the Union, is as follows :

Wheat	11.56	bushels.	Barley............	19.14	bushels.
Indian Corn.....	28.00	"	Buckwheat.. ...	17.68	"
Rye	13.30	"	Potatoes	93.22	"
Oats................	23.95	"	Hay...............	1.28	tons.

The above averages show conclusively that there is a great necessity for a more extended use of manufactured manures.

Even Pennsylvania, that boasts of her fertile soils and the perfection of her system of agriculture, produces only the following average of the above named crops per acre :

Wheat................	12.8	bushels.	Indian Corn......	35.0	bushels.
Rye	13.0	"	Oats	27.8	"
Barley......	21.4	"	Buckwheat..... ..	16.5	"
Potatoes	88 0	"	Hay............ ...	1.3	tons.

But this will favorably contrast with South Carolina, which shows the lowest average production, as follows:

Wheat..............	5.6	bushels.	Corn......	10.2	bushels.
Rye	5.0	"	Oats..........	9.7	"
Barley	9.0	"	Potatoes	101.0	"

INORGANIC ELEMENTS.

TABLE showing the amount of inorganic and mineral substances usually found in 100 pounds of the plants named, in their marketable condition; serves as a key to the application of the proper elements as fertilizers.

	Chlorine.	Lime.	Magnesia.	Silica.	Oxide of Iron.	Potash.	Soda.	Phosphoric Acid.	Sulphuric Acid.
Wheat	0.01	0.09	0.31	0.07	0.02	0.80	0.08	1.00	0.12
Wheat straw	0.07	0.40	0 17	4.77	0.05	0.79	0.11	0.37	0.17
Rye	0.02	0.07	0.23	0.52	0.02	0.57	0.09	0.91	0.50
Rye straw	0.07	0.41	0.15	3.01	0.04	0 80	0.11	0.27	0.10
Barley	0.02	0.05	0.17	0 53	0.01	0.44	0.14	0.67	0.12
Barley straw	.. ...	0.44	0.14	3.44	.. ..	1.29	0.24	0.27	0.22
Oats	0.01	0.11	0.21	0.13	0.01	0.46	0.07	0.63	0 45
Oat straw	0.16	0.37	0.19	2.47	0.04	1.00	0.30	0.20	0.16
Buckwheat	.. ...	0.13	0.20	0.02	0.02	0 17	0.40	1.00	0.44
Buckwheat straw	0 46	1.10	0.21	0.33	.. ...	2.76	0.13	0.61	0.31
Indian corn	0.08	0.03	0.27	0 08	0.02	0.52	0 26	0.89	0.10
Corn stalks	.. ..	0.59	0.31	2.72	0.09	1.99	0.07	0.45	0.28
Peas	0.04	0.14	0.19	0.02	0.02	1.00	0.08	0.87	0.11
Pea straw	0.31	1.94	0.36	0.27	0.07	1.07	0 98	0.35	0.30
Beans	0.02	0.25	0.17	0.24	0.09	1.34	0.05	0 96	0.13
Bean straw	0.43	1.51	0.43	0 33	0.10	1.96	0.52	0.47	0.13
Potatoes	0.01	0 01	0.02	0.01	0 06	0.20	.. ...	0.06	0.02
Beets	0 01	0.03	0 04	0.02	0 04	0.21	0.05	0.06	0.02
Carrots	0.04	0.09	0 04	0.02	0.07	0 29	0.16	0.08	0.05
Turnips	0.03	0.08	0.02	0.01	0.02	0.32	0.06	0.07	0.08

Table showing the percentage of moisture; of albuminous and glutinous compounds; of starch, gum, sugar and woody fibre; and of ash and nitrogen, and the equivalent in ammonia contained in the different products. It also shows their relative value as food:

	Moisture.	*Albuminous and Glutinous Compounds.*	*Starch, Gum, Sugar, and Woody Fibre.*	*Ash.*	*Total.*	*Nitrogen.*	*Equivalent in Ammonia.*
Common Grass............	48.00	2.06	47.74	2.20	100.00	0.33	0 40
Clover Hay	16.00	8.12	68.38	7.50	100.00	1.30	1.58
Barley Straw...............	10.94	1.80	82.12	5.14	100.00	0.35	0.42
Oat Straw.....................	8.25	2.15	84.50	5.10	100.00	0.39	0.47
Wheat Straw...............	6.42	1 80	86.66	5.12	100.00	0.35	0.42
Corn Stalks..................	10.20	1.08	83.22	5.50	100.00	0.24	0,29
Carrots.	85.20	1.50	12.40	0.90	100.00	0.24	0.29
Turnips.......	90.43	1.35	7.72	0.50	100 00	0.21	0.25
Potatoes.......................	75.00	2.20	21.90	0.90	100.00	0.35	0.42
Peas......	10.80	23 40	62.70	3.10	100.00	3.74	4.54
Beans	8.75	22.81	65.04	3.40	100.00	3.65	4.43
Indian Corn.................	15.00	11.25	70.75	3.00	100.00	1.18	1.43
Rye.........	10.00	10.57	77.33	2.10	100.00	1.69	2.05
Oats	10.10	14.20	67.20	3.50	100.00	2.27	2.75
Barley..........................	8.75	14.50	73.10	3.65	100.00	2.32	2.81
Wheat..................	8.55	19.50	69.10	2.85	100.00	2,41	2.92
Buckwheat.	5.20	9.50	83.10	2.20	100.00	1.52	1.84
Rice.........	15.10	6.27	78.23	0.40	100 00	1.00	1.21
Cotton Seed Cake.........	12.00	35.00	34.50	4.50	100.00	5.60	6.80

Plants by their vital force assimilate the elements of both the soil and atmosphere, and turn these elements into food for herbiverous animals, which in turn also serve for food for the carniverous animals and man, thus to borrow a simile, if we take a field and plant grass, and put a dog thereon he will starve, put a sheep, and the sheep will eat the grass, and then serve as food for the dog.

The organic portions of plants are, as we have said, derived from the atmosphere, and are built up into

1st. *Albumen and gluten*, which contain nitrogen, and whose percentage in any grain is the test of its food value.

2d. *Starch, sugar, gum, and oil*, which are rich in carbon, and whose functions are chiefly to make fat, and so to sustain the necessary heat of animals. This oil, or fatty matter, renders the grains in which they are found more easy of digestion, as in corn and the yolk of an egg.

Carniverous animals are nearly destitute of fat, and should an animal be debarred from exercise, and fed on grain rich in carbon as corn, it rapidly increases in fat, as the carbon is not burnt out by the lungs, but is deposited in the tissures.

3d. *Woody fibre*, which is the part of plants that sustain them in their erect posture. This is also rich in carbon, but is not readily assimilated so as to serve for animal food. The tender shoots, however, of young trees are consumed by animals, of this material also paper is made, and in the laboratory of the chemist it can be turned into starch or sugar.

Fourth and last portion is *moisture*, which constitutes the largest part by weight of nearly all plants and animals.

CHAPTER V.

COMPONENTS OF FERTILIZERS AND WHERE FOUND.

From the preceding tables it will be seen how much mineral matter is carried away by crops, and it can readily be understood that this deficiency cannot possibly be restored to the soil by atmospheric action. Therefore it becomes necessary that those elements which are in least quantity should be artificially returned.

These substances are phosphoric acid, potash, ammonia, and lime.

All experience has demonstrated that stable manure is about the best thing to restore worn out lands, and if enough of it could be gotten there could be no use for the commercial fertilizers of the market. But it cannot be obtained, and therefore the farmer should try to save all he has and to make it go as far as possible by the use of adjuncts.

The reason why this manure is so useful is because it contains *all* the elements of plant food in an easily soluble condition. Solubility is nothing but minute division and the mineral refuse of the animal having passed through the system, has been acted upon by all the acids of the digestive organs, and is most minutely divided.

But even stable manure can be helped for those plants which require some particular element, in large quantity, by adding that element to it in the compost pile. Thus all cereals requiring large quantities of phosphoric acid and potash would be increased in yield by the addition of a high grade superphosphate, yielding a large amount of phosphoric acid, as the Etiwan Dissolved Bone, or better, by the Etiwan Crop Food, containing both phosphoric acid and potash in large quantities.

We have said the principal elements to be restored to land are phosphoric acid, phosphate ammonia, and lime. Let us first examine the sources from which the farmer can obtain them on his own farm.

His home resources of supply of phosphoric acid are very small, as will be seen from the accompanying tables.

Potash can be obtained in fair quantities from ashes and the leaves of trees. But where the timbers supply a good ash, the soil, generally, contains a sufficient supply of potash.

The barn-yard is also a good source of supplying the same.

Ammonia is abundantly supplied by cotton seed, stable, and barn-yard manure. Nature also supplies an indeterminate quantity of this valuable gas from the atmosphere, which supply is brought by rain and dews, and is also absorbed by the humus, or organic portions of soils.

This amount of ammonia, which is variable in fact, varies from day to day, so that it is easy to see how useless would be the analyses of a soil to determine its fertility.

While ammonia is necessary for all crops, and in comparatively large quantities for the cereals, any farmer who grows cotton, and economizes his home supply, need never purchase a single pound.

Lime is easily gotten in many places from marl, or from burnt lime. The remarkable action often seen from an application of this substance, can in no wise be explained by the idea of its simple deficiency in the soil. It is caused mainly by its chemical action, by decomposing the organic and mineral constituents of the soil, thus setting free plant-food which had been previously insoluble.

These different substances have very different chemical actions when mixed, and if done ignorantly may result injuriously. Thus, lime or ashes, mixed with ammoniacal compounds, sets the ammonia free, and it flies off into the air, so that in a compost of an easily decomposable substance, such as stable or farm-yard manure, or cotton seed, lime and ashes, should be excluded, and some retaining substance, such as dissolved bone or land plaster applied.

The former preferable on account of the phosphoric acid contained, which unites at once with the ammonia, while the latter depends on a double decomposition. In the Etiwan Dissolved Bone both are present in large quantity, and have a powerful effect.

The farmer thus should have two piles. In one of which he puts his easily decomposable substances, such as cotton seed, stable, and barn yard manure, with Dissolved Bone, which can be used in from three to four weeks, or less time ; and another, in which are put all the straw, corn stalks, cotton stalks, leaves, fence corner scrapings, muck, or swamp mud, etc., with lime and ashes. This should be kept wet with water and with all the drainings of the laundry and kitchen, and should be turned or repiled in from four to six months, at which time Dissolved Bone should be added in liberal quantities.

This is more fully explained in a subsequent chapter on composting.

To show the value of the different substances which can be obtained upon the farm, we give below some tables indicating their analyses.

The following table shows the per centage of the substances named, contained in the different varieties of leaves in their dry state :

	Phosphoric Acid.	Potash.	Lime.
Mulberry Leaves....	0.36 per cent.	0.69 per cent.	0.90 per cent.
Horse-chestn't ".....	0.61 "	1.47 "	3 04 "
Walnut ".....	0.28 "	1.86 "	3.76 "
Beech "	0.28 "	0.35 "	3.03 "
Oak ".....	0.40 "	0.17 "	2.38 "
Fir ".....	0.23 "	0.14 "	0.58 "
Red Pine ".....	0.48 "	0.09 "	0.88 "

The following table shows the amount of phosphoric acid and potash cotained in one hundred pounds of the different varieties of ashes named, together with their values:

	Phosphoric Acid.	Potash.	Value of 100 lbs.
Beech....................	5.3 lbs.	16.1 lbs.	$1.51
Birch	8.5 "	11.6 "	1.45
Oak....................	5.5. "	10 0 "	1.05
Walnut....................	12.2 "	15.3 "	1-77
Poplar	13.1 "	14 0 "	1.71
Apple	4.6 "	12.0 "	1.16
Red Pine	5.1 "	5.2 "	.64
Coal ashes (*anthracite*)..........	.5 "	0.15 "	.3
Peat "	2 0 "	0.2 "	.11

We shall now show the value of one thousand pounds of well rotted and air-dried stable manure, calculated from the analyses of Dr. Vœlcker :

Water and organic volatile matter	670 lbs.	
Ammonia....................	30 "	$7.50
Phosphoric Acid....................	18 "	2.25
Potash	20 "	1.60
	Total	$11.35

We shall now give the value of the urine of different animals, as shown by the fertilizing salts contained in one thousand pounds of each :

	Water.	Phos'ric acid.	Potash.	Nitrogen.		Ammonia.
Pig Urine...	9.29 lbs.	trace,	6.0 lbs.	11.8 lbs.	=	14.3 lbs.
Horse " ...	9.40 "	trace,	2.8 "	15.4 "	=	18.7 "
Cow " ...	9.28 "	trace,	4.5 "	4.4 "	=	5.3 "
Sheep " ...	9.65 "	1.3 lbs.	7.2 "	13.1 "	=	15.9 "
Human " ...	9.57 "	4.0 "	2.0 "	1.42 "	=	17.2 "

The following table shows the amount produced annually by a single animal of the kind named, and its value as manure, when fermented :

	Yearly amount.	Phosphoric Acid.	Potash.	Ammonia.	Value.
Pig Urine...	1000 lbs.	trace,	6.0 lbs.	14.3 lbs.	$4.00
Horse " ..	2000 "	trace,	5.0 "	37.4 "	9.79
Cow " ..	2000 "	trace,	9.0 "	8.8 "	2.92
Sheep " ..	500 "	0.6 lbs.	3.6 "	8.0 "	2.35
Human " ...	750 "	3.0 "	1 5 "	10.7 "	3.16

The following table shows the amount of water and of the valuable constituents only contained in 1,000 lbs. of dung of the animals named in its natural or undried state :

	Water.	Phosphoric acid.	Potash.	Nitrogen.	Ammonia.
Pig Dung	840 lbs.	8 0 lbs.	5.0 lbs.	7.0 lbs.=	8.5 lbs
Horse "	743 "	12.2 "	28.0 "	5.4 " =	6.5 "
Cow "	864 "	5 2 "	10.7 "	3 5 " =	4.2 "
Chicken ".........	850 "	15.2 "	5.5 "	21.5 " =	26.1 "
Sheep ".	670 "	22.7 "	7.0 "	7.1 " =	8.5 "
Human "........	750 "	3.3 "	1.0 "	15.0 " =	18.2 "

The following table shows the amount produced annually by a single animal of the kind named, and its value, assuming the phosphoric acid to be soluble, and the nitrogen as actual ammonia.

	Amount.	Phosphoric acid.	Potash.	Ammonia.	Value.
Pig..........	200 lbs.	1.6 lbs.	1.0 lbs.	1.7 lbs. =	$0.62
Horse......... .	2,000 "	24.4 "	56.0 "	13.0 " =	9 94
Cow	2,000 "	10.4 "	21.0 "	8 5 " =	5.15
Chicken	5 "	0.076 "	0,03 "	0.13 " =	.04
Sheep...............	50 "	1.27 "	0.35 "	0.42 " =	.42
Human....... . ..	100 "	0.33 "	0.10 "	1.80 " =	.50

The solid and liquid excretions taken together, will show the following annual value of each animal :

Pig	Excrements,	solid and	liquid..	$ 4.62
Horse	"	"	"	19.73
Cow	"	"	"	8.07
Sheep	"	"	"	2.75
Human	"	"	"	3.66

It is exceedingly important that all these solid and liquid excrements should be retained, and for this purpose the stable and barnyard should be well littered, and the litter gathered up and placed under cover—as the most valuable ingredients are soluble in water, and would be leached out by rains.

If the interior of a pile of manure becomes too dry, decomposition will cease, and the manure become "fire-fanged"* when water should be poured on. The object to be obtained being not too much nor too little water.

CHAPTER VI.

THE ART OF COMPOSTING.

It is from the neglect of this highly useful and important art that our planters and farmers are responsible for so many sterile and uncultivated fields, and for so many high-priced and complicated fertilizers. As long as the planter takes from his fields all that they will bring and carries it away, so long will the land that he plants become poorer and poorer, until cropping is unremunerative.

This is the present condition of most of the lands in the Southern Atlantic States; and in order to compete with the great cotton States of the Southwest, our planters have to furnish to their lands nearly *all* the elements required for plant food.

Hence has sprung up a trade in so called "Commercial Fertilizers," in which *all* these elements, or the most important of them, are, or are said to be. These different elements occur in commerce in many and various forms, and are brought from different and widely separated places, so that to obtain them, import them, combine them, and sell them, requires considerable knowledge, judgment, capital and skill. It is evident that if any of these ingredients can be furnished and combined by the planter, the resulting fertilizer will be cheaper, and the saving will be proportional to the cost of the ingredient.

If the *whole* crop were returned to the field as manure, *all* the ingredients would be furnished for the succeeding one; but in practice *some* (and that generally the richest in plant food) is exported, and the residue is too often tossed aside and neglected. Thus all that the planter can do is to save *some* of this plant food, while a large part of that exported has still to be bought from a manufacturer of those particular elements.

Now it so happens that those elements which the planters

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†Having a dry frosted appearance.

can save, are just the most expensive of those which he purchases, so that it becomes a most important point for him to consider the ways and means by which this saving of those elements can be effected. This is the art of composting.

Nothing in this world is easy; and all things to be well done, must be done with accurate knowledge and careful judgment. The art of composting is no exception to this, and in order to compost intelligently, the planter must know something about the chemistry of organic and inorganic substances, and the laws by which he must work. As, owing to the great differentiation of knowledge, we cannot expect all planters to acquire this knowledge, it becomes the duty of the chemist to interrogate nature, study her laws, and then impart to him the result.

All plants or portions of them when they die, and are left exposed to air and moisture, undergo decomposition, that is the highly complex arrangement of their atoms is broken up, and more simple forms are assumed.

This decomposition may take place in two ways: First, by eremacausis, or slow decay, which is an oxidizing process; second, by putrefaction or fermentation, which is a reducing process · the only difference between putrefaction and fermentation being that in the former offensive odors are emitted, and in the latter, none.

Eremacausis requires an excess of free oxygen, and therefore, takes place in bodies freely exposed to the air, while putrefaction, though it seems to require oxygen to commence, only proceeds in the absence of oxygen, or at least when that element is present only in small quantity. Thus, if we take a substance undergoing slow decay, and exclude the atmosphere, putrefaction sets in; and *vice versa*, if we take a body in putrefactive decomposition, and expose it freely to the air, the rapid decomposition ceases, and slow oxidation ensues.

The final results of these two methods of decomposition differ considerably, and are of especial importance, in this inquiry.

In eremacausis, or slow decay, the carbon and oxygen unite to form carbonic acid; the hydrogen and oxygen to form water, while nearly all the nitrogen escapes as free gas, a small portion only forming nitric acid; while in putrefaction a portion only of the carbon unites to form carbonic acid, some of it escaping in combination with hydrogen as marsh gas, some as carbonic oxide, while a large portion remains as humus. The hydrogen also, though mostly combining as water, yet also forms marsh gas, and remains as one of the elements of humus; while *all* the nitrogen unites with hydrogen to form ammonia.

Thus it appears that the object of the planter should be to arrange his materials so as to produce putrefaction, and at the same time to retain those valuable products which may escape as gas or in solution in drainage water.

The materials to be used, are nearly all the refuse of the farm, stable, cattle-pen, kitchen, and house; the only things to be avoided, are wood ashes and lime; these must not be put in a heap, because they evolve ammonia from any combination in which it is, but if they are desired on the land, can be sprinkled after ploughing and previous to harrowing, the lime, especially, doing most good when kept near the surface. Weeds also after seeding, should be excluded; as they will give endless trouble when they sprout.

Straw, corn-stalks, cotton-stalks, muck, clearings of fence corners, leaves, all are useful; but in the South, the cheapest, most abundant, and most valuable ingredient is cotton seed; here we have an inexhaustible supply of that most costly ingredient, ammonia, and also a considerable amount of potash and phosphoric acid; and it is to this compost that we now direct your attention.

If cotton seed were wetted, piled, and left, in a short time it would "heat," and putrefaction setting in, nearly all the nitrogen would escape as ammonia, while the other inorganic matters in small quantity, would be left ready for the next crop. The object, therefore, to be attained, is to retain the ammonia in an available state, and to increase the amounts of the other valuable elements. The one in least quantity is phosphoric acid, so that the object resolves itself, into retaining the ammonia of the seed and adding soluble phosphoric acid. This is done by composting the cotton seed with the soluble phosphoric acid of the manufacturer; and it is evident that the greater the percentage of soluble phosphoric acid in the purchased article, the greater the percentage of ammonia and soluble phosphoric acid in the compost. The ordinary way of retaining ammonia escaping from a compost heap, is to sprinkle with plaster, or put a layer of earth. In the former case a mutual decomposition ensues, and sulphate of ammonia and carbonate of lime are formed; while in the latter case, the gas is absorbed by the earth, with probably the same and also other chemical reactions.

In the retention, by means of the dissolved bone or acid phosphates of commerce, both phosphoric acid plaster being present, the ammonia can be retained both as phosphate and sulphate, so that there is very little danger of any of it escaping into the atmosphere and being lost.

For the construction and management of a compost heap, the following mode of procedure is recommended:

In selecting the location, a slight incline should be chosen; and from any point as a centre, lay off on each side four feet; now dig a small ditch on the centre line, say twelve inches deep, and twelve inches wide, as long as may be necessary, and sink a barrel or keg at its mouth to catch the drainings; slope down the space from each outside line of the four feet radius to the ditch, and if the planter be thrifty, cover loosely with plank the whole bottom; haul the materials to the spot, and commence building the pile from below upwards.

Having thoroughly soaked the cotton seed with all the water it will absorb, mix it intimately with the dissolved bone, and build up the pile to any convenient height, like the roof of the house, giving enough slope to shed rain; finish each section to the top, sprinkle on the outside with dissolved bone, and cover with hay or straw like a stack; then proceed in like manner with the next section above; the advantage of *finishing* each section being that decomposition starts sooner, so that by the time the last section is done, the first will the sooner be ready; neatly finish up the job and leave to nature.

In about a week or ten days, active putrefaction has set in and the interchange of elements above referred to goes on. The, drainage water in the barrel should be poured back on the pile from time to time, and the interior of the pile examined as to its temperature and dampness, by running a small grooved pole into it; should it be dry, and not moist, all action will cease, and water should be poured on the top; after the interior of the seeds is disintegrated, the heat diminishes, and the compost may be used; but if the pile be composed of material other than cotton seed, and not so easily decomposable (such as straw. leaves, etc.,) when the heat nearly ceases, the pile should be turned.

It is sometimes asked whether the mixture of seed and dissolved bone could not be as advantageously made in the soil; but it would appear not, for the following reasons:

If the mixture is made in the soil, the conditions are more favorable for eremacausis, or slow decay, than for putrefaction, owing to the more free access of oxygen; so that the nitrogen of the seed would go off as free gas, and any of it that would be inclined to form ammonia, from putrefaction occurring in some portion of the mass, would be induced by the presence of the carbonated bases in the soil to form nitric acid, which is much more readily lixiviated than ammonia. As also in the germination of seeds some nitrogen escapes as free gas, so in the soil, where the germination would proceed farther than in the pile, more nitrogen would be lost.

In the pile, the seed, owing to moisture, sprouts, and the young plant, from contact with the acid of the dissolved bone, and from a want of oxygen, light, and from the heat, dies, and is then subject to the laws of putrefactive decomposition; the valuable nitrogen uniting with hydrogen to form ammonia, which is immediately seized by the phosphoric acid and retained, the matter may be thus tabulated:

Objections against mixing in the Soil.	*Points in favor of the Pile.*
Loss of Nitrogen.	Nitrogen saved as Ammonia.
Less Humus.	Humus formed.
Formation of Nitric Acid rather than Ammonia.	Rapid decomposition.

In conclusion, the writer would suggest that the planters make some comparative experiments on the two modes, and give information as to the results; for though the chemical theory may be in favor of the pile, the difference in the yield of the crop may not compensate for the greater expense of composting.

DIRECTIONS TO MAKE AND MANAGE A COMPOST PILE.

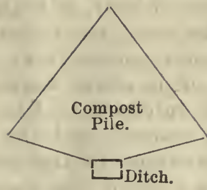
Select a slight incline, if possible, and from any convenient point dig a ditch up the hill, say ten inches wide and six deep, as long as may be necessary, and sink a keg at the mouth to catch the drainings. If the country be flat, just give the ditch a slight inclination to the keg, and locate the spot for the pile where the rain water will flow away from the pile and not make a boggy place,

Now, on each side of the ditch, say six feet, lay off a line parallel to the ditch, with a string or pegs, and slope down the ground from each of these lines to the ditch, so that all the drainings will flow into the ditch; cover the whole bottom with plank, taking care to cover the ditch so that the drainage water can get into it, and at the same time that it will not be choked by the compost falling into it.

Now, in order to build up the pile straight, erect a temporary barricade with plank across the ditch, some two or three feet up hill from the keg; this can easily be done by putting two or three saplings in the ground for posts, bracing them from below, and resting the plank against them.

Now haul the materials to the spot, and commence building the pile from the barricade upwards.

Having thoroughly soaked the cotton seed with all the water it will absorb, mix it intimately with an equal weight of dissolved bone, and throw it against the barricade; build up the pile in sections, of say six feet, to any convenient height, sloping the sides so as to shed rain. Finish each section to the top, sprinkle the outside with dissolved bone, and cover with boards or with hay or straw, like a stack; then proceed in like manner with the next section above; the advantage of *finishing* each section being, that decomposition starts sooner; so that by the time the last section is done, the first will be the sooner ready. A diagram would then look thus:



VIEW FROM LOWER END.

The water which collects in the keg should not be suffered to waste, but should be poured back on the pile from time to time, and the cover of the pile be opened for the purpose; and the temperature and dampness of the interior should be examined by running a small grooved pole into the mass at different places, twisting it round and round and withdrawing it, so as to bring out some of the stuff in the middle; if this be dóne skilfully, the planter can ascertain the condition of each individual inch from the outside to the centre. If anywhere the interior be found dry, water should be poured on the top over the part so found; and when the interior of the seeds are thoroughly disintegrated, and the heat has nearly ceased, the compost may be used.

If at any time the smell of ammonia is perceived, the part from which it emanates should be carefully ascertained and more dissolved bone put on, or a layer of earth.

The proportions of dissolved bone and seed may be varied from those recommended above, but the dissolved bone should not be less than one-fourth of the weight of compost, provided the dissolved bone be one of a high grade of soluble phosphoric acid, The Etiwan Dissolved Bone contains the highest percentage of soluble phosphoric acid in the market.

THE APPLICATION OF COMPOSTED FERTILIZERS TO DIFFERENT GRADES OF LANDS.

BY A FARMER.

The only Commercial Fertilizers our people habitually compost are the different superphosphates. For this purpose it is earnestly recommended to you to get the highest grade of dissolved bone in your reach, as a dissolved bone of 24 per cent. solubility is worth twice as much as an acid phosphate of 12 per cent. solubility. Hence, 100 lbs. of the former will go as far as 200 lbs. of the latter. Many farmers used low grade acid phosphates, 200 lbs. to the acre, and alongside the same number of lbs. of a dissolved bone, of high grade, and at the end of the year came to the conclusion that they are about equal in value. This conclusion comes from the fact that the acid phosphate was enough, or, in other words, had sufficient available phosphoric acid and sulphate of lime, while the other contained more than was wanted, and the excess was not taken up by the plant, but remained in the soil, where it is true it would not be lost, but remain the valuable property of the owner of the soil.

As our capitals are short we are not able to make such large investments, and should only buy, pay for, and apply what will be returned to us in the crops of this year. It is true that high manuring will pay, but equally true that it will only pay when followed by a high state of cultivation and deep ploughing, etc: and, even then, it is not certain to pay, except on lands that have been brought up for some years past, and which are in a high state of cultivation, in farming language—well in heart—well educated lands.

For the ordinary field crops of cotton, from 75 to 150 lbs. of a high grade manipulated Fertilizer will pay a better dividend on the money invested than will 200 lbs. A bale of cotton requires only about fourteen lbs. of phosphoric acid and about eighteen lbs. of potash to make it. A 24 per cent. dissolved bone will yield eleven lbs. per 100 of phosphoric acid, and we can always trust the soil to supply some; hence, until all the other ingredients of the soil, the seasons, etc., are sufficient to produce over one bale per acre, 100 lbs, will be found enough for common plantation use, and especially for the common field cultivation in vogue amongst us. Practical farmers will find 150 lbs., perhaps, the best quantity to apply.

It will be best to concentrate your cotton seed and stable manure, supplying ammonia, on your poorer lands, and to use the Dissolved Bone on your fresh and improved lands. To ald the inexperienced, we give below a table for six different soils.

	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.
	lbs. per acre	lbs. per acre	lbs. per acre	lbs. per acre	lbs. per acre	lbs. per acre
Dissolved bone, 24 per cent......	150	150	150	150	150	150
Cotton seed..............................	1000	800	500	300	....	....
Phosphoric acid........................	16½	16½	16½	16½	16½	16½
Sulphate lime........................	67½	67½	67½	67½	67½	67½
Ammonia from cotton seed about	30	24	15	9	....	....
Potash from cotton seed about...	7½	6	4	2	....	....

No. 1 represents very poor and exhausted lands; Nos. 2 and 3 better grades; No. 4 a good old land, capable of producing or growing a cotton stalk, without any fertilizer, eighteen to twenty inches high ; Nos. 5 and 6, rich old lands, new grounds and bottom lands. The first line in the table shows the maximum amount of Dissolved Bone of twenty-four per cent. solubility recommended for an acre ; the second line the amount of cotton seed for same ; the third line the amount of phosphoric acid, in pounds, supplied by 150 pounds Dissolved Bone, twenty-four per cent.; the fourth line the amount of sulphate of lime, or land plaster, supplied by 150 pounds Dissolved Bone; the fifth line the amount, in pounds, of ammonia, approximately, supplied by number of pounds of cotton seed above, in same column ; the sixth line the amount of potash in pounds, approximately, supplied by the cotton seed in column above.

Lands of the classes five and six will make crops without ammonia, and generally, except when sandy, have a sufficient supply of potash. Of course the farmer may vary this formula, and may substitute stable manure, in whole or in part, for cotton seed.

In the sand region, or on porous soils, it will be best to use Dissolved Bone and potash combined. This can be readily obtained by purchasing the Etiwan Chemical Crop Food.

It may not be amiss for me to add that strong stable manure and cotton seed are about equal to each other in value, so far as ammonia is concerned.

CHAPTER VII.

COMMERCIAL FERTILIZERS.

The raw materials used in the manufacture of commercial fertilizers are the different Phosphates of Lime, Ammoniacal matters, Salts of Potash, Sulphuric Acid, and Nitrate of Soda.

The sources of the chief class, that is the phosphates, are all natural, being bone black, ashes, apatite, phosphorite, coprolites, and the various " marl stones " and " rock guanos."

Bone Black.—This material, also known as animal charcoal, is made by calcining or burning raw bones in a closed retort, so as to drive off all volatile matter except carbon and phosphate of lime. This residue, when ground, is sold to sugar refineries for decolorizing their solutions. After having been used and " revived " several times, its bleaching power is exhausted, and it is then sold either as a manure itself or to the manufacturer of superphosphates.

Bone Ash is a greyish white powder, obtained by calcining or burning raw bones in an open vessel, so that by the free access of oxygen all the carbon, organic matter and moisture is driven off, and but the mineral matter remains. This is composed almost entirely of phosphate of lime and magnesia. The supplies of this material mostly come from the La Plata districts of South America and the Baltic, Mediterranean and Black Sea ports. In this manufacture large amounts of ammonia are lost. These two materials, bone black and bone ash, have the phosphate of lime, in a peculiarly sensitive or assimilative condition, and it would be profligate to use them as raw materials for conversion into superphosphates. It seems as if the passing through the animal economy renders phosphate of lime sensitive to assimilation. It is only to be regretted that the available supply of these materials is so very limited.

Apatite.—This is a hard mineral, sometimes crystalized, at others conchoidal. It is generally found in thin seams of crystalline or volcanic rocks. It varies in color from light green to iron stone red. The principal localities in which it is found is Northern Europe, Canada, New York, and New Jersey. The close structure of this mineral, even when finely powdered, makes it unsuited for direct application to soils, and the commercial supply is limited, owing to the inaccessibility of its sources. Its conversion into superphosphate of lime is also attended with many manufacturing difficulties.

Phosphorite.—This substance is very much like the preceding. It is fibrous in structure, a light yellow color, and very hard; generally found in thick beds, surrounded by apatite and quartz. It derives its name from becoming phosphorescent when heated; and the best qualities come from Spain and Bavaria.

The supply of this article is also very limited, owing to difficulty in mining.

The German, French, and Prussian phosphorites are also in the market—but, as a general rule, the percentage of bone phosphate of lime is too low to make them an economical source ot supply, the percentage of sand especially being so large.

Coprolites—True coprolites are not fossil excrements, but worn and rounded fragments of fossil bones. They are chiefly found in England, France, and Germany, and, to a small extent, in Canada. They contain large amounts of fluoride of calcium, carbonate of lime, oxide of iron, and alumina. They do not make a good superphosphate, and are not as good for this purpose as the South Carolina phosphate. Nevertheless, in England they are extensively employed, on account of their abundance and cheapness.

Rossa, or Guayamas Guano.—This is a very superior rock guano, from the Island of Rossa, in the Gulf of California.

It is peculiar in that it contains a portion of its phosphate of lime in the bi-calcic, or "reduced," state, and is almost wholly free from foreign constituents. It is in hard lumps, but easily powdered.

Sombrero.—This is a rock guano, which constitutes the entire structure of one of the windward Islands in the Caribbean Sea. It is somewhat hard, and forms a light yellow powder when ground. It is not near so available for a superphosphate as South Carolina phosphates. Owing to the large amount of oxide of iron, there is a great waste of acid in the manufacture; dangerous compounds are formed, such as copperas and the superphosphate "goes back."

Navassa Guano.—This comes from an Island off the coast of Hayti. It contains a large amount of phosphate of lime, but owing to the abundance of iron and alumina, its conversion into a superphosphate entails a large waste of acid, difficulty of manufacture, and the inevitable "going back" in large quantities.

Orchilla Guano.—This material comes from an island in the Caribbean Sea. It is a damp, fawn colored powder. It is loose in texture, and could be applied directly to the soil, but its low percentage of phosphate of lime renders its money value small, and for conversion into superphosphates, the large amounts of carbonate of lime, iron and alumina, renders it uneconomical.

There are also on the market the Phœnix Island, Guanahaui, Redonda, St. Martin's, and other phosphatic rock guanos, all of which, together with those above named, are inferior in fertilizing properties to the South Carolina phosphates.

South Carolina Phosphates.—This material comes from the vicinity of the Ashley and other rivers west of Charleston. It is ground without difficulty, and is readily soluble in acids. Of all the mineral phosphates of lime which are available, these are best suited for conversion into superphosphates.

The mining and manufacture of these has assumed enormous dimensions, some $20,000,000 being invested and the works for the production of superphosphates and manipulated fertilizers are among the most complete and well arranged in the world. The combined capacity of the acid chambers is about 800,000 cubic feet: the largest single chamber being that of the Etiwan Company, who convert one hundred tons of sulphur per month into acid.

They also manufacture the highest grades of superphosphates on the market.

We here give a table of the analyses of these different Phosphatic Guanos:

Analytical Table of the Comparative Composition of the Natural, Crude Phosphates of Lime.

COMPONENTS.	Rosa Guano from the Gulf of California. (Morfit.)	Apatite from Canada. (T. S. Hunt.)	Apatite from Norway. (Voelcker.)	Phosphorite from Spain. (Ogston.)	Phosphorite from Germany. (Fresenius.)	Bone-Ash from South America. (Morfit.)	Bone-Black from Sugar Refineries. (Morfit.)	Sombrero Guano. (Morfit.)	True Coprolites, Cambridge. (Way.)	False Coprolites, Suffolk. (Herepath.)	Marlstones, or South Carolina Phosphate. (Morfit.)	Cooperite, or Navassa Guano. (Morfit.)	Orchilla Guano. (Morfit.)
Bone or tri-phosphate lime and magnesia	53.08	91.20	90.74	80.68	74.64	70.31	58.10	67.06	57.09	55 49	52.21	46.80	45.84
Neutral or diphosphate lime	18.03	....	....	....	....	....	....	....	....	....	....	....	....
Carbonate lime	....	....	....	4.26	3.43	10.82	8.80	5.34	13.27	13.40	} 14.32	1.92	19 61
Lime with organic acids, silica, & alumina	....	....	4.59	1.83	1.34	.79	....	6.97	3 41	....		10 37	2.74
Fluoride calcium	....	7.60	....	.11	5.26	....	....	....	4.33	1.43	....	....	....
Chloride calcium	....	.78	1.61	....	....	....	....	....	....	1.66	....	....	....
Phosphate alumina	....	....	} 1.66	....	....	....	....	3.62	5.57	5.12		6.78	
Phosphate iron	....	....		....	....	....	....	1.95	1.78	1.61		3.20	
Oxide aluminium	0.25	....	traces	} .50	1.08	} .60	....	3.13	2.14	.80	} 8.89	11.62	} 11.36
Oxide iron	0.15	....	....		6.42		....	1.10	traces	traces		3 70	
Sulphate lime	8.10	....	....	....	....	....	....	.86	.80	.70	....	1.02	....
Potassa salts	} .30	....	....	....	0.58	} .20	} .80	} .49	.61	.65	....	....	....
Soda salts		....	....	....	0 52				....	....	....	traces	....
Organic matters	9.80	....	....	....	....			5.36			8.00	6.02	6.93
Water, constitutional	} 3.62	....	....	....	....	} 8.42	} 8.60	....	} 4.05	} 6.26	....	....	....
Water, accidental		....	0.43	.20	2.45			3.52			3.05	4.74	12.54
Carbon	....	....	....	....	....		19.50	....	....	....	....	....	....
Sand and silica	6.20	0.90	1.64	12.34	4 83	9.20	4.00	.68	6.93	12.45	13.96	4.50	1.24
	99.53	100.48	100.67	99 92	100 55	100.34	99.80	100.08	99.98	99,57	100.43	100.67	100.26

Peruvian Guano. The first commercial fertilizer known to the people of the South, now totally exhausted, came from the Chincha Islands, off the coast of Peru, and is believed to have been derived from the excrement of the fish eating bird, known on that coast as the Guano. Owing to the total want of rain the ammoniacal and other valuable salts which are soluble, were preserved. Genuine guano was exceedingly light, weighing only sixty-eight to seventy-two pounds per bushel.
And its average composition was about—

Water expelled at 212°	12.42
Organic matter and ammoniacal salts	52.98
Yielding ammonia	17 21
Phosphate Lime and Magnesia	25.06
Alkaline salts	8.26
Insoluble matter	1.50

From the above analysis we perceive that this substance was remarkably rich in fertilizing materials, all of which were in a readily soluble condition. It is to be regretted that these deposits are totally exhausted, the mining having extended down to the rock, so that the last shipments made contained over thirty per cent. of rock.

Other localities have been discovered yielding the same substance, but of a less valuable composition, as the Guanape islands, off the coast of Ecuador, were, owing to the heavy dews and occasional rainfall, the ammoniacal and soluble salts are considerably diminished in quantity. While it may be obtained to analyze fourteen per cent of ammonia, its amount of soluble phosphorie acid is small. Nor does it appear to compare with the Chincha Island Guano, as a fertilizer, at all relatively to their analysis.

Lower down the Coast of South America, off Chili, islands are found containing quantities of guano nearly entirely destitute of ammoniacal and soluble salts, owing to the frequent rains. Quite recently another deposit has been discovered on the Falkland Islands and off the West Coast of Africa, of the same character.

All of these are the raw materials which enter into the manufacture of commercial fertilizers.

For the manufacture of superphosphates alone in this country, the South Carolina and Navassa phosphates are the only ones almost exclusively used. The source of ammonia for the manipulated fertilizers is chiefly a material called Azotin, which is composed of the dried flesh of animals; dried blood is also a limited supply. In these materials the nitrogen does not exist in the form of ammonia, but is converted into that compound by decomposition.

The different preparations of fish which are found on the market are intended to supply both phosphoric acid and ammonia, but their chief value is for a supply of the latter. If applied alone to the soil, it benefits those crops which require larger amounts of ammonia; but as the bones of the fish are not comminuted or finely ground, the phosphoric acid contained therein is of scarcely any use to growing plants, and the amount required for the crop must be drawn from the store house of the soil.

This has been sought to be remedied by treatment with sulphuric acid previous to manipulation, but as the bones exist as bones, and not as powder, the solvent power of the acid is materially diminished.

The best grade of this material is what is known as fish scrap, as fish guano proper is nearly all water.

Planters are often of the opinion that a bad smell arising from a fertilizer is a test of its manurial value, and especially that it indicates the presence of ammonia. This is entirely a mistake; the smell of ammonia is that of hartshorn, and in any fertilizer in which the ammonia exists as free carbonate of ammonia, this smell will be observed, as in Guanape guano. If, however, the ammonia, is combined with a strong acid, no smell of hartshorn will be perceived as in the true Chincha or Peruvian guano, or in sulphate of ammonia.

The cause of the bad smell is not exactly ascertained, but seems to be due to the presence of the gases, sulphuretted and phosphoretted hydrogen, which gases are combinations of sulphur and phosphorus with hydrogen. The sulphuretted hydrogen is familiar as the odor of rotten eggs.

Sulphate Ammonia is also a very concentrated supply of this material for crops. It is chiefly made from the refuse of gas works of large cities. Coal, from which gas is made, was originally organic matter—trees, plants. These contained nitrogen, and when subjected to heat, in a closed retort, the nitrogen combines with the hydrogen to form ammonia. This, together with all the tarry matters of the coal distils over, and is condensed in the "hydraulic main," which is a necessary process in gas making. The liquor containing most of the ammoniacal salts is then drained off, treated with sulphuric acid, and evaporated until the sulphate of ammonia crystalizes. It is allowed to cool, and is drained. The supply of this, however, is limited, and its chief use is for the cereal crops, to which it is better adapted than to cotton.

Nitrate of Soda.—Ammonia has generally been considered the form in which nitrogen is assimilated by crops, but nitrogen in the form of nitric acid, or any of the compounds of oxygen and nitrogen, gives excellent results, so that nitrate of soda forms one of the most regular and best supplies for nitrogen for plants. This material is entirely obtained from the rainless desert of Atacama, in Peru. It there exists in vast beds, and is mined, refined, and exported to foreign markets. It is indispensable in the manufacture of sulphuric acid, and is also used in the manufacture of gunpowder, by being previously turned into nitrate of potash, by a treatment with German muriate of potash. It absorbs moisture, and so cannot be used alone for gunpowder. Its chief effect appears to be upon grass crops, but the difficulty attending its use is that it more readily leaches out of soils than ammoniacal salts, so that where it has been applied to a field, it is almost always to be detected in ditches, draining the same.

Nitrate of Potash.—This material is a valuable source of both nitrogen and potash. It is chiefly imported from India, and, on account of its price, only used for gunpowder or medicine.

Ammoniacal Plants.—Another source of ammonia, and by far the least expensive to the farmer to supply his land with, will be found in several plants, to be turned under as green crop. Amongst these, we find in our section of country red clover and peas, which appear to absorb nitrogen from the atmosphere, and, by some process, to store it in the soil. It is also asserted by an eminent chemist that some species of grass, weeds, and especially the vetch, accomplish the same result.

Potash.—The supply of potash in the commercial fertilizers is almost entirely derived from the German Stassfurt salts. Here it is found in beds consisting of alternate layers of common salt and the salts of lime, magnesia and potash. It was evidently produced by the drying up of an inland sea. It has to be mined and refined, when different grades are exported to foreign markets. The best grade exported is the muriate, containing from forty-five to fifty per cent. pure potash. Of late years the unmanufactured salt has been largely exported and highly praised, but, in our opinion, a large amount of chloride of magnesium present would render it injurious to most crops. Many of these lower grades are sold under the name of Kainit.

The soils which are first exhausted of potash are, first, sandy; second, light clay; third, marly; fourth, heavy clay and alluvial.

Sulphate Lime, Gypsum, or Land Plaster.—This is extensively applied to soils as a manure, and is also found largely in all high grade superphosphates, or dissolved bone, as resulting from the process of their manufacture. It really seems to be a specific for a clover crop, and its general action appears to be its power of fixing the ammonia contained in the soil and atmosphere. In the presence of carbonate of ammonia a double decomposition ensues, resulting in the formation of sulphate of ammonia and carbonate of lime. This substance, calcined or burned, makes plaster of Paris.

CHAPTER VIII.

THE MANUFACTURE OF COMMERCIAL FERTILIZERS.

Previous to the formation of the Sulphuric Acid and Superphosphate Company, it was maintained that the manufacture of Sulphuric Acid was impracticable in the latitude of Charleston, S. C.; but the projectors of this Company, appreciating the great advantage of manufacturing the acid near to the raw material, and seeing no scientific reason why it could not be done, applied for a charter under the above name on May 26th, 1868.

In selecting a site for their works the greatest pains were taken, and the most advantageous locations in South Carolina and the adjoining States were carefully considered. After mature deliberation, a point on the east of Charleston Neck, about four miles from the city, and lying on "Town Creek," a branch of Cooper River, was selected. This spot was where the "John Adams," the first frigate of the United States, was built, and where subsequently was the Confederate Navy shipyard. The Creek is bold and deep, affording excellent harborage, and of depth sufficient to allow any ship to come to the Company's wharf which shall cross Charleston Bar.

At this spot, on the 21st August, 1868, work was begun; and on December the 8th, of the same year, the first Sulphuric Acid was manufactured south of Baltimore.

The manufacture of fertilizers is by no means so easy a thing as some suppose, and the difficulties increase as the grade rises, in more than a geometrical ratio. This Company started out with the determination to make the highest grade of Soluble Phosphoric Acid possible for the South Carolina Phosphates; and after meeting and surmounting innumerable obstacles, both seen and unforseen, turned out the highest grade fertilizer ever manufactured in America. The good done the country by this action is incalculable, for since that time the grade of all fertilizers manufactured in the United States has steadily improved, and to-day the farmers and planters of America have offered them commercial fertilizers not excelled by any made either in England or on the Continent.

The process of manufacuure may be divided into four heads:

1st. The Manufacture of Sulphuric Acid.

2d. The Drying and Grinding of the Rock.

3d. The Mixing.

4th. The Disintegrating and Screening.

The Manufacture of Sulphuric Acid;

Sulphuric Acid is a solid dissolved in a variable quantity of water, and consists of sulphur and oxygen, so that the object in the manufacture of Sulphuric Acid is to make the oxygen of the atmosphere combine with sulphur in the presence of sufficient water to give it the required strength.

If sulphur be burnt in the open air, it combines with two-thirds of the oxygen necessary to make Sulphuric Acid, and is called Sulphurous Acid; the last third cannot be made to combine directly from the atmosphere, and so means have been devised by which it may be made to do indirectly; these are the introduction of Nitric Acid vapor into a mixture of Sulphurous Acid and atmospheric air and steam; the Nitric Acid parts with some of its oxygen to the Sulphurous Acid, which, becoming Sulphuric Acid, dissolves in the steam and falls as a rain, while the Nitric Acid takes back from the atmosphere the oxygen which it had lost, to give it again to another portion of Sulphurious Acid, thus acting as a carrier of oxygen between the two.

All these conditions are ensured in the construction and management of the Sulphuric Acid "chambers," as they are called. These chambers are vast rooms, whose sides, top and bottom, are composed of sheet lead, and all along on the outside run steam pipes for the admission of steam into the interior; anteterior to the chambers is the furnace in which the sulphur is burnt and the Nitric Acid evolved.

This Company has two sets of chambers, of an aggregate capacity of 180,000 cubic feet, and their consumption of sulphur per day of twenty-four hours is 7,200 lbs. The set last erected contains the largest single chamber in the United States, having the following dimensions: 140 feet x 30 x 25; while the furnace of cast-iron is the only one in America, and the largest in the world. They have also attached to their chambers the condensers of Gay Lussac, thus reducing their consumption of Nitre from 10 per cent. to 4 per cent., and their production is from 280 to 285 lbs. of Monohydrated Sulphuric Acid to the hundred pounds of sulphur consumed.

Drying and Grinding.—The rock, as it comes from the washers of the miners is loaded on sloops, schooners and flats, and transported to the wharf of the Company, where it is discharged by a derrick, which is driven by a wire rope 320 feet from the engines. A shed 200 feet long, paved with brick and supported by iron pillars, extends backwards from the wharf. On this brick pavement is laid two rows of pine wood; overhead is a railroad, on which run the cars into which the rock is discharged, and from which it is dumped upon the wood beneath. When the cargo has been thus discharged, the wood is set fire to and the "kiln" burns and is dried; by the well considered arrangements of this Company, the consumption of wood is reduced to one cord of wood to forty tons of rock, thus obviating some of the damage done by too much heat, while the rock is still thoroughly dried.

The dried rock is loaded into cars, which is then hoisted up an inclined plane into the mill, and dumped by the crushers. These are three in number, made of iron, by Baugh & Sons, of Philadelphia, and are mounted on heavy frames, independent of the mill building; they are driven by belts from the main shaft, and run at a speed of 450 revolutions per minute; a man feeds these crushers with the dried rock, which passing though crushed, is picked up by elevators and delivered into the hoppers of the mill-stones.

Of these mill-stones there are six pair; they are of the best French buhr stone, and are driven by the crank shaft of one engine; they are four feet in diameter and are make 170 revolutions per minute. The amount ground depends entirely upon the degree of fineness to which it is ground; in this mill the rock is ground so that all will pass through a screen of 80 wires to the inch, and the product is about 3 tons per pair of stones per day of 10 hours. After passing through the stones the powdered rock is received into elevators which deliver it into a box through which it is screwed from the mill house into the mixing house at an elevation of about 30 feet, and there is delivered, not having been touched by hand since it was fed as crude rock to the crusher.

The mixing is done in a tub of cast iron 8 feet in diameter, which revolves 20 times per minute, and in which are small ploughs, which revolve 160 times per minute. Into this tub a weighed quantity of the powdered rock is thrown by simply overturning a large scoop, which hangs from a steelyard, the scoop and steelyard being suspended from a frame which runs on a trainway from the pile of ground rock to the mixing tub; a known weight of acid is now run in and the revolving ploughs thoroughly incorporate the phosphate and the acid. When a certain time has passed, an iron plug, which stops up a hole in the centre of the tub, is raised and the mixed mass, either in a semi-fluid or dry condition, depending on the amount of acid added, falls through into a space below. The amount of acid which is mixed with the phosphate depends upon the grade of solubility desired, the higher the percentage of Soluble Phosphoric Acid wanted the larger the amount of acid to be added, and here is the chief difficulty in the manufacture, for the higher the grade the more pasty is the mass, and, therefore, the more difficult is the after manipulation; up to 5 per cent. of Soluble Phosphoric Acid the mass comes from the mixing tub dry, and can be screened at once and packed in sacks; but when enough acid is added to render 11, 12, and 13 per cent. soluble, the mass comes from the mixing tub a semi-fluid and will flow like mud 30 or 40 feet, and must be left for a time varying, from two weeks to two months, to harden before it can be handled; the intermediate grades also of 6, 7, and 8 per cent., when left, harden into a rock as solid as limestone, and have to be disintegrated in a powerful machine. These difficulties have all been overcome by this Company, and they are now able to ship 13 per cent. of Soluble Phosphoric Acid in three days from the time of the order; this is called by them the Etiwan Dissolved Bone; they also manufacture an ammoniated fertilizer, called the Etiwan, by adding to the mass in the mixing tub the proper quantities of Peruvian Guano, Ammoniacal Matter, and German Potash Salts; they also employ a Chemist to analyze all material received, prescribe all formulas, and to analyze the fertilizers when ready for market; every ingredient is most carefully weighed and the results scientifically scrutinized. Their laboratory is among the most complete in the South, and as a fertilizer company they rank among the foremost in the world.

The disintegrating and screening is the last process in the manufacture; the mass from the mixing tub, after standing for a time, is mined out and loaded in cars, which are elevated to a machine called the disintegrator; of these there are two—one imported from England, and the other made in Baltimore; this machine consists of two wheels, one within the other, and revolving vertically in opposite directions. The stuff is fed in at the centre, dashed to pieces by the bars at the periphery, and falling through these is received in a revolving screen, after passing through which it is ready for market.

The power of driving all this machinery consists of two 80 and 100 horse power respectively, the former being made in Connecticut and the latter in Charleston. There is a set of boilers for each engine, and also another single one to generate steam for the chambers; but the steam pipes are so arranged that any engine can be run from any boiler. Of donkey water pumps there are three—one small one to supply the boilers; one of 450 gallons a minute capacity, which supplies a tank 65 feet high, from which water pipes are distributed all over the works; and one of 1,200 gallons a minute capacity for fire insurance. There is also a donkey air pump which pumps air into a boiler in which it is retained under a pressure of 50 pounds to the square inch, and from which it is drawn for the purpose of forcing the acid up to the mixing tub and condensing towers. There are also, five heaters through which passes the escape steam from the engines and which heats the feed water to 200° Fahr., thus saving much fuel.

The Works are also connected with the South Carolina and Northeastern Railroads by a track laid down by the Company, so that they ship directly from their Works to any point in the interior.

To the east of the Works, on a point commanding a most beautiful view of the harbor and sea, are four dwelling houses, in which live the families of seven of the white employees of the Company, including the Superintendent, Engineer, and sulphur burners, so that at all times the property of the Company is protected by the presence of a large number of intelligent and efficient men ; the roofing of the different buildings covers an acre and a half of ground, and the total horse-power of all the engines is 320.

The only dangerous material used is the Nitrate of Soda, which is the source of the Nitric Acid, used in the chambers; and this is stored in a fire-proof brick magazine.

The capacity of these Works, for the high grade which they make, is 850 tons per month of the Etiwan Dissolved Bone, and 1,000 tons per month of their ammoniated fertilizer, the Etiwan.

APPENDIX.

TABLE I.

Composition of the Ash of Agricultural Plants and Products, giving the average of all trustworthy Analyses published up to August, 1865, by Professor Emil Wolff, of the Royal Academy of Agriculture, at Hohenheim, Wirtemburg.*

No.	Substance.	No. of Analyses.	Per cent. of Ash.	Potash.	Soda.	Magnesia.	Lime.	Phosphoric Acid.	Sulphuric Acid.	Silica.	Chlorine.
	I.—MEADOW HAY AND GRASSES.										
1	Meadow hay	13	7.78	25.6	7.0	4.9	11.6	6.2	5.1	29.6	8.0
2	Young grass	1	9 32	56.2	1.8	2.8	10.7	10.5	4.0	10.3	2.0
3	Dead ripe hay	1	7.73	7.6	2.9	3.4	12.9	4 4	0.7	63.1	5.7
4	Rye grass in flower	4	7.10	24 9	4.2	2.1	7.5	7.8	3.8	39.6	5.4
5	Timothy	3	7.01	28.8	2.7	3.7	9 4	10.8	3.9	35.6	5.0
6	Other sweet grasses	39	7.27	33.0	1.8	2.6	5.5	7.8	4.4	37.6	4.1
7	Oats heading out	6	9.46	41 7	4.4	3.5	7.0	8.3	3.4	27.9	4.4
8	" in flower	7	7.23	39.0	3.3	3.2	6.7	8.3	2.7	33.2	4.0
9	Barley heading out	5	8.93	38.5	1.7	2 9	7.0	10.1	2 9	31.2	5.6
10	" in flower	5	7.04	26.2	0.6	3.1	6.0	9.8	2.9	48.0	3.5
11	Winter wheat heading out	2	9.73	34.7	1.9	1.5	4.9	7.4	2.8	41.9	5.3
12	" " in flower	3	6.99	25.7	0.5	2.2	3.1	7.3	1.9	56.8	2.8
13	Winter rye heading out	1	5.42	38.6	0.3	3.1	7.4	14 7	1.6	32.0	... ..
14	Green cereals, light	5	7.20	29.6	1.5	3.9	6.6	9 1	4.1	41.4	4.3
15	" " heavy	5	9.21	35.6	3.4	4.7	8.3	8.1	4.8	30.0	5.6
16	Hungarian millet, green (*panicum germ*)	2	7.23	37.4	... ..	8.0	5.4	5.4	3.6	29.1	6.4
	II.—CLOVER AND FODDER PLANTS.										
17	Red clover	56	6.72	34.5	1.6	12.2	34.0	9.9	3.0	2.7	3 7
	a. 15-25 per cent. potash	15	6.01	20.8	1.9	18.2	39.7	9 4	3.8	1.2	5.4
	b. 25-35 " " "	23	6.74	29.8	1.6	11.8	35.6	10.6	3.0	2.7	2.9
	c. 35-50 " " "	18	7.19	46.3	1 4	7.8	27.3	9.2	2.2	2.5	3.2
18	White clover	2	7.16	17.5	7.8	10.0	32.2	14.1	8.8	4.5	3.2
19	Lucerne	7	7.14	25.3	1.1	5.8	48.0	8.5	6.1	2.0	1.9
20	Esparsette	2	5.39	39.4	1.7	5.8	32.2	10.4	3.3	4 0	3.0
21	Swedish clover	2	5.53	33.8	1.5	15.3	31.9	10.1	4.0	1.2	2.8

*From Prof. Wolff's *Mittlere Zusammensetzung der Asche, aller land und forstwirthschaftlichen wichtigen Stoffe*, Stuttgart, 1865. The above table being more complete, and in most particulars more exact than the author's means of reference enable him to construct, and being moreover likely to be the basis of calculations by agricultural chemists abroad for some years to come, has been reproduced here literally. The references and important explanations accompanying the original, want of space precludes quoting. In the table, oxide of iron, an ingredient normally present to the extent of less than one per cent., is omitted. Chlorine is often omitted, not because absent from the plant, but from uncertainty as to its amount. Carbonic acid is also excluded in all cases, for the sake of uniformity and facility of comparison.

COMPOSITION OF THE ASH OF AGRICULTURAL PLANTS AND PRODUCTS.

No.	Substance.	No. of Analyses.	Per cent. of Ash.	Potash.	Soda.	Magnesia.	Lime.	Phosphoric Acid.	Sulphuric Acid.	Silica.	Chlorine.
	II.—CLOVER AND FODDER PLANTS.										
22	*Anthyllis vulneraria*............	1	5.60	10 3	4.5	4 6	68.9	7.0	1.6	2 9	0.2
23	Green vetches.....................	2	8.74	42.1	2 9	6.8	26.3	12 8	3.7	1.8	3.1
24	Green pea in flower	1	7.40	40.8	0.2	8.2	28.7	13 2	3 5	2.6	1.8
25	Green rape, young	5	8 97	32.3	3 8	4.5	23.1	8.7	16.3	3.2	7.6
	III.—ROOT CROPS.										
26	Potatoes......	31	3.74	59.8	1.6	4.5	2.3	19.1	6.6	2 3	2 8
27	Artichokes	1	5 16	65.4	.....	2.7	3 5	16.0	3.2	......	2 4
28	Beets........	15	6.86	53.1	14.8	5.1	4.6	9.6	3.3	3.3	6 6
29	Sugar Beets.......	44	4.35	49.4	9.6	8.9	6.3	14.3	4.7	3.5	2.0
30	Turnips.............................	15	8.28	39.3	11 4	3.9	10.4	13.3	14 3	2.4	4.1
31	Turnips*..........................	2	7.20	50.6	3.8	2.1	13 4	17.4	6 0	1.1	6.4
32	Ruta-bagas........................	2	7.68	51.2	6.7	2.6	9.7	15.3	8.4	0.5	5.1
33	Carrots......	10	6.27	36.7	22 1	5.3	10.7	12.5	6 4	2.0	3.2
34	Chickory..........................	7	5.21	40 4	7.7	6.3	8.7	14.5	9.2	6.1	3 7
35	Sugar beet-heads†................	1	4 03	29.6	24.4	11.0	9 1	12.8	7.6	2.0	0.5
	IV.—LEAVES AND STEMS OF ROOT CROPS.										
36	Potatoes, August.................	3	8.92	14 5	2.7	16.8	39.0	6.1	5 6	8.0	4 6
37	" October..............	1	5.12	6.3	0.8	22.6	46.2	5 5	5 5	4.2	3.0
38	Beets................................	6	15 96	29.1	21.0	9.7	11.4	5.1	7 4	4.8	11.3
39	Sugar Beets........................	7	17.49	22.1	16.8	18.3	19.7	7.4	8.0	3.1	5.7
40	Turnips.............................	16	13.68	22.9	7.8	4.5	32.4	8.9	9.9	3.8	8.2
41	Kohl-rabi..........................	1	16.87	14.4	3 9	4 0	33.3	10.4	11.7	10 5	3.9
42	Carrots..............................	7	13.57	14.1	23.1	4.6	33.0	4.7	7.9	5.6	7.1
43	Chickory...........................	1	12 46	60.0	0.7	3.2	14.3	9.0	9 0	1 0	1.7
44	Cabbage............................	2	10.81	48.6	3.9	3.3	15.3	15.8	8.5	1.2	2.5
45	Cabbage stalk.....................	1	6.46	43.9	5 5	4.1	11.3	20.9	11.8	1.1	1.2
	V.—REFUSE AND MANUFACTURED PRODUCTS										
46	Sugar beet cake..................	7	3.15	36.6	8.4	5.6	25.3	10.2	3.9	6.2	4 8
	a. Common cake................	2	3.03	25.0	12.7	......	27.2	12.9	5.8	......	13.0
	b. Residue of maceration......	2	3.53	35.3	9.4	11.8	27.9	6.0	2.3	.....	0 9
	c. Residue from Centrifugal machine.....................	1	3.11	45.5	9.8	......	25 3	13.0	6 5	......	... ..
47	Beet molasses....................	3	11.28	71.1	10.5	0.4	6.0	0 5	2.1	0.7	10.1
48	Molasses slum‡..................	1	19.02	89.8	......	0.9	.....	0.1	1.7	......	1.6
49	Raw beet sugar..................	1	1.43	33.3	28.0	......	8.5	......	22 9	0.9	5.8
50	Potatoe slum‡.....................	1	11.10	46.3	6.6	8.8	6.2	20.0	7.3	3.4	2 1
51	Potatoe fiber‖.....................	4	0.99	15.6	......	7.6	47.8	23.9	......	3.1	1.3
52	Potatoe juice¶.....................	2	23.45	69 5	......	3.5	1.0	16.3	3.6	0.1	7.5
53	Potatoe skins§.....	3	9.59	72.0	0.7	6.7	9.6	3.4	0.4	2.7	2 1
54	Fine wheat flour..................	1	0.47	36.0	0.9	8.2	2.8	52.0	......	......	......
55	Rye flour...........................	1	1.97	38.4	1.8	8.0	1.0	48.3	......	......	......
56	Barley flour.......................	1	2.33	28.8	2.5	13.5	2.8	47.3	3 1	......	......
57	Barley dust**......................	1	5.62	18.9	1.4	7.7	2 5	28.9	......	20.0	......
58	Maize meal........................	1	....	28.8	3.5	14.9	6.3	45.0	......	......	......

* White turnips in the original, but apparently no special kind. † Probably the crowns of the roots, removed in sugar making. ‡ The residue after fermenting and distilling off the spirit ‖ Refuse of starch manufacture. ¶ Undiluted. § From boiled potatoes. ** Refuse in making barley grits.

Composition of the Ash of Agricultural Plants and Products.

No.	Substance.	No. of Analyses.	Per cent. of Ash.	Potash.	Soda.	Magnesia.	Lime.	Phosphoric Acid.	Sulphuric Acid.	Silica.	Chlorine.
V.—REFUSE AND MANUFACTURED PRODUCTS.											
59	Millet meal	1	1 35	19 7	2.3	25.8	......	47.3	2.7	......	......
60	Buckwheat grits	2	0 72	25.4	5 9	12.9	2.3	48.1	1.7	.....	1.6
61	Wheat bran	1	6.43	24.0	0.6	16.8	4.7	51.8	......	1.1	......
62	Rye bran	1	8.22	27 0	1.3	15.8	3.5	47.9	......	......	......
63	Brewer's grains	2	5.17	4 2	0.8	10.1	11 6	38.0	0.8	32.2	......
64	Malt	1	2.78	17 3	... ..	8.4	3.8	36.5	......	33.2	......
65	Malt sprouts	1	6.56	34.9	......	1.4	1.5	21 0	6.3	29 5	......
66	Wine grounds	1	4.60	53.4	0.5	3.2	15.5	15.5	7.8	......	0.5
67	Grape skins	2	4 04	49.4	2.2	6.1	13 0	20.8	4.4	3.5	0.6
68	Beer	1	....	37.5	7.8	4.9	2.2	32 7	......	10 2	......
69	Grape must	6	....	62.8	0.9	5.6	4.9	17.7	6 5	1.3	0 6
70	Rape cake	2	6.59	24 3	0.1	11.5	10.9	36.9	3.3	8.7	0 2
71	Linseed cake	1	6.24	23.3	1.4	15.9	8.6	35.2	3.4	6.5	0.6
72	Poppy cake	1	10 60	20 8	4 5	4.3	28.1	37.8	2 0	4 8	......
73	Walnut cake	1	5 36	33.1	......	12 2	6.7	43.8	1.2	1 6	0 2
74	Cotton seed cake	1	6.95	35 4	......	4.3	4 6	48.3	1 1	4.0	......
VI.—STRAW.											
75	Winter wheat	12	4.96	11.5	2.9	2.6	6.2	5.4	2.9	66.3	......
76	Winter rye	6	4 81	18.7	3.3	3.1	7.7	4.7	1.9	58 1	......
77	Winter spelt	2	5.56	11.2	0.4	0.9	4.8	6.3	1 8	71.4	......
78	Summer rye	3	5.55	23 4	......	2 8	8.9	6.5	2.6	55.9	......
79	Barley	17	5.10	21.6	4 5	2.4	7 6	4.3	3.7	53.8	......
80	Oats	6	5.12	22.0	5.3	4.0	8.2	4.2	3.5	48.7	......
81	Maize	1	5.49	35.3	1.2	5.5	10 5	8.1	5.2	38 0	......
82	Peas	21	5.74	21.8	5 3	7.7	37 9	7.8	5 6	5.7	6 1
83	Field bean	4	7.12	44.4	3 8	7.8	23.1	7.0	0.2	5.4	13.8
84	Garden bean	5	6.06	37.1	6.0	5.2	27.4	7.8	3.6	4.7	5.2
85	Buckwheat	6	6.15	46.6	2.2	3.6	18.4	11.9	5.3	5.5	7.7
86	Rape	12	4.58	25.6	10.3	5.7	26.5	7.0	7 1	6.7	12 4
87	Poppy	1	7.86	38.0	1.3	6.5	30.2	3.5	5.1	11.4	2.5
VII.—CHAFF, ETC.											
88	Wheat	1	10.73	9.1	1.8	1.3	1 9	4.3	......	81.2	......
89	Spelt	2	9 50	9.5	0.3	2.5	2.4	7.3	2 3	74.2	......
90	Barley	1	14.23	7.7	0.9	1.3	10.4	2.0	3 0	70.8	......
91	Oats	1	9.22	13.1	4.8	2.6	8.9	0.3	2.5	59 9	......
92	Maize cobs	1	0 56	47 1	1.2	4.1	3 4	4 4	1.9	26 4	......
93	Flax seed hulls	1	6.62	31.1	4 3	2 8	29.6	2.8	4.8	17.2	6 1
VIII.—TEXTILE PLANTS, ETC.											
94	Flax straw	8	3 71	36.9	5.1	7.1	22.3	11.5	5.3	6.0	4.0
95	Rotted flax stems	2	2.40	9.0	4.8	5.4	51.4	5.9	3.1	13.8	......
96	Flax fibre	3	0.67	3.3	3.2	5.4	63.6	10.8	2.7	6.2	0.4
97	Entire flax plant	2	4.30	34.2	4.8	9.0	15.5	23.0	4.9	2.6	5.9
98	Entire hemp plant	2	4.60	18.3	3.2	9.6	43.4	11.6	2.8	7.6	2.5
99	Entire hop plant	1	9.87	26.2	3.8	5.8	16.0	12.1	5.4	21.5	4.6
100	Hops	12	6.80	37.3	2.2	5.5	16.9	15.1	2.6	15.4	3.4
101	Tobacco	7	24.08	27.4	3.7	10.5	37.0	3.6	3.9	9.6	4.5
IX.—LITTER.											
102	Heath	8	4.51	13.2	5.3	18.4	17.8	5.1	4.4	35.2	2.1
103	Broom (*Spartium*)	2	2.25	36.5	2.5	12.4	17.1	8.6	3.5	10.3	2.7
104	Fern (*Aspidium*)	5	7.01	42.8	4.5	7.7	14.0	9.7	5.1	6.1	10.2

COMPOSITION OF THE ASH OF AGRICULTURAL PLANTS AND PRODUCTS.

No.	Substance.	No. of Analyses.	Per cent. of Ash.	Potash.	Soda.	Magnesia.	Lime.	Phosphoric Acid.	Sulphuric Acid.	Silica	Chlorine.
	IX—LITTER.										
105	Scouring rush (*Equisetum*)...	2	23.77	13.2	0.5	2.3	12.5	2.0	6.3	53.8	5.7
106	Sea weed (*Fucus*).............	8	14.39	14.5	24.0	9.5	13.9	3.1	24 0	1.7	10.1
107	Beech leaves in autumn.......	6	6 75	5 2	0.6	6.0	44 9	4.2	3 7	33.9	0 4
108	Oak " "	1	4.90	3.5	0.6	4.0	48.6	8.1	4.4	30.6	......
109	Fir " (*Pinus sylvestris*)	1	1.40	10.1	......	9 9	41.4	16.4	4.4	13.1	4.4
110	Red pine leaves (*Pinus Picea.*)	1	5.82	1.5	......	2.3	15.2	8.2	2.8	70.1	......
111	Reed (*Arundo phrag.*)..[*ria*	1	4.69	8.6	0.2	1.2	5.9	2.0	2.8	71.5	......
112	Down Grass (*Psamma area-*	1	.. . .	29 8	4 0	3.8	16 5	7.2	3 6	18.5	......
113	Sedge, (*Carex*)................	11	8.08	33.2	7.3	4 2	5.3	6.7	3.3	31.5	5.6
114	Rush (*Juncus*)................	7	5 30	36.6	6.6	6 4	9 5	6.4	8 7	10.9	14.2
115	Bulrush (*Scirpus*)..............	2	8.65	9 7	10.3	3.0	7.2	6.5	5.6	43.3	......
	X.—GRAINS AND SEEDS OF AGRICULTURAL PLANTS.										
116	Wheat	78	2.07	31.1	3.5	12.2	3.1	46.2	2.4	1.7	......
117	Rye............................	14	2.03	30.9	1.8	10.9	2.7	47.5	2 3	1.5	......
118	Barley.........................	34	2 55	21.9	2.8	8.3	2.5	32 8	2.3	27.2	......
118	Oats	20	3.07	15.9	3.8	7.3	3.8	20.7	1.6	46.4	......
120	Spelt with husk	2	4.20	17.3	1.8	5.8	2.6	20.0	2 6	44.0	......
121	Maize..........................	8	1.42	27.0	1.5	14.6	2 7	44.7	1.1	2.2	......
122	Rice with husk	3	7.84	18.4	4.5	8.6	5.1	47.2	0.6	0.6	......
123	" husked	3	0.39	23 3	4.8	13.4	2.9	51.0	0.6	3.0	......
124	Millet with husk..............	2	4.49	11 9	1.0	8.4	1.0	23.4	0 2	52 3	......
125	" husked.................	1	1.42	18.9	5 8	18 6	......	53 6	1.5	......	......
126	Sorghum.......................	1	1.86	20.3	3.3	14.8	1 3	50.9	......	7.5	... ..
127	Buckwheat.....................	2	1.07	23 1	6.2	13.4	3 3	48.0	2.1	......	1.7
128	Rape seed.....................	15	4 24	23.5	1.1	12.2	13.8	43.9	3.6	1.1	0.3
129	Flax "	3	3.65	32.3	1.8	13.2	8 4	40.4	1 1	1.1	0.1
130	Hemp "	2	5 48	20.1	0.8	5 6	23.5	36.3	0 2	11 8	0 1
131	Poppy "	1	6 12	13.6	1.0	9.5	35.4	31.4	1 9	3 2	4 4
132	Madia "	1	....	9.5	11.2	15.4	7.7	55.0	......	......	......
133	Mustard "	3	4.30	15.9	5.8	10.2	18.8	39.0	4.7	2.4	0.4
134	Beet "	1	5.66	18 7	17.3	18.9	15.6	15.5	4.2	2.1	9.4
135	Turnip "	1	3 98	21.9	1.2	8.7	17.4	40.2	7.1	0 7	......
136	Carrot "	1	8.50	19.1	4 8	6.7	38.8	15.8	5 6	5.3	3.3
137	Peas "	30	2.81	40.4	3.7	8.0	4 2	36.3	3.5	0.9	2 3
138	Vetches........................	1	2 40	30 6	10.6	8.5	4.8	38.1	4 1	2.0	1.1
139	Field Beans....................	6	3 45	40.5	1.2	6.7	5.2	39 2	5.1	1.2	2.9
140	Garden "	9	3.06	44.1	2.9	7.5	7.7	30.4	3.8	0 8	0.9
141	Lentils	1	2.06	27.8	9 9	2.0	5.1	29.1	......	1.1	3.3
142	Lupines	1	....	33.5	17.8	6 2	7.8	25.5	6.8	0.9	1 8
143	Clover seed....................	3	4.11	37.3	0.6	12.2	6 2	33 5	4.7	2.4	1.3
144	Esparsette seed................	1	4 47	28.6	2 8	6.6	31.6	23.9	3.2	0.8	1.1
	XI.—FRUITS AND SEEDS OF TREES, ETC.										
145	Grape seeds....................	2	2.81	28.6	......	8.6	33.9	24 0	2.5	1.1	0 3
146	Alder..........................	2	5 14	37 6	1 6	8.0	30.7	13.0	3.4	3 2	0.1
147	White pine.........	1	....	21.8	7.1	16.8	1.5	39 7	......	11.7	0.3
148	Red pine......................	1	....	22.4	1.3	15.1	1.9	46.0	......	10.4	......
149	Beech nuts	1	3.30	22 8	10.0	11.6	24.5	20.8	2.2	1.9	0.5
150	Acorns	2	....	64.5	0.7	5.4	7.0	16.2	2.8	1.1	1.7
151	Horse chestnut	2	2 36	58.9	......	0.5	11.6	22.4	1.4	0.2	6.4
152	" green husk	2	4.38	76.4	......	1.0	10.0	6.3	1.4	0.6	5.6

Composition of the Ash of Agricultural Plants and Products.

No.	Substance.	No. of Analyses.	Per cent. of Ash.	Potash.	Soda.	Magnesia.	Lime.	Phosphoric Acid.	Sulphuric Acid.	Silica.	Chlorine.
	XI.–FRUITS AND SEEDS OF TREES, ETC.										
153	Apple, entire fruit............	1	....	35.7	26.1	8.8	4.1	13.6	6.1	4.3	......
154	Pear, "	1	....	54 7	8.5	5 2	8.0	15 3	5.7	1.5	......
155	Cherry, "	1	....	51.9	2 2	5 5	7.5	16.0	5.1	9.0	1.1
156	Plum, "	1	....	59.2	0.5	5.5	10.9	15.1	3.8	2.4	.. ...
	XII.—LEAVES OF TREES.										
157	Mulberry	3	3.53	19 6	......	5.4	25.7	10.2	0.5	33.5	0.1
158	Horse chestnut, spring.......	2	7.17	38.8	......	3 9	21.3	23 4	6.0	2.9	3.8
159	" autumn.....	1	7.52	19.6	......	7.8	40.5	8.2	1.7	13.9	4.1
160	Walnut, spring................	1	7.72	42.7	......	4.6	26.9	21.1	2 6	1.2	0.5
161	" autumn..............	1	7.01	26.6	......	9.8	53 7	4.0	2.7	2.0	0.8
162	Beech, summer...............	2	4.83	18.5	1.8	8.6	36.5	7.8	3.1	15.2	1.2
163	" autumn.................	6	6.75	5.2	0.6	6.0	44 9	4.2	3.7	33.9	0 4
164	Oak, summer..................	1	4.60	33.1	.. ...	13.5	26.1	12.2	2.7	4.4	0.1
165	" autumn..................	1	4.90	3.5	0.6	4.0	48.6	8 1	4.4	30.9	......
166	Fir, autumn......................	1	1.40	10.1	......	9.9	41.4	16.4	4.4	13.1	4.4
167	Red pine, autumn.............	1	5.82	1 5	......	2.3	15 2	8.2	2.8	70.1	......
	XIII.—WOOD.										
168	Grape............................	8	2.75	29.8	6.7	6.8	37.3	12.9	2.7	0.8	0.8
169	Mulberry	1	1.60	6.5	14.3	5.7	57.3	2.2	10.3	3 6	4.2
170	Birch...............................	2	0.31	11.6	5.8	8.9	60.0	8 5	0.3	4.8	0.6
171	Beech, body-wood.............	2	0.65	16.1	3.4	10 8	56 4	5.3	1.0	4 7	0.1
172	Beech, small-wood............	1	1.05	15.2	2.1	16 8	45.8	11.6	0.7	6 7	0.1
173	" brush......................	1	1.45	14.1	2.2	10.8	48.0	12.3	1.2	9.8	0.1
174	Oak, body-wood....... [bark	2	....	10.0	3.6	4.8	71 5	5.5	1.4	1.1	0.1
175	" small branches with	1	......	19.8	....	7.5	54.0	9.3	1 6	3.1	......
176	Horse chestnut twigs, autu'n.	1	3.31	19.4	....	5 2	51.0	21.7	......	0.7	1.4
177	Walnut twigs, autumn.......	1	2 99	15.3	......	8.1	55 9	12.2	3.2	2 9	0 3
178	Poplar, young twigs.....	5	....	14.0	0.4	7 5	58.4	13.1	1.5	2.0	0.1
179	Willow, " "	1	....	11.4	5.6	10.1	50.8	16 4	3 1	0.7	0.6
180	Elm, " "	1	......	24.1	2.1	10 0	37.9	9.6	5.4	6.2	6.7
181	Elm, body-wood..................	1	....	21.9	13 7	7.7	47.8	3.3	1.3	3.1	......
182	Linden	1	....	35.8	6.0	4.2	29.9	4.9	5.3	5.3	1.5
183	Apple tree...............	2	1.29	12.0	1.6	5.7	71.0	4.6	2.9	1.8	0 2
184	Red pine........................	1	0.25	5.2	26.8	6.2	47 9	5.1	3.0	2.0	4.0
185	White pine......................	2	0.28	15.3	9.9	5.9	50.1	5.5	3 0	6.0	0.2
186	Fir..................................	6	0.31	11.8	4.6	9.1	50 1	5.8	2.3	15.0	0.4
187	Larch	1	0.32	15.3	7.7	24.5	27.1	3.6	1.7	3.6	0.6
	XIV.—BARK.										
188	Birch	2	1.33	3.8	5.4	8 2	45.6	7.3	1.3	20.1	1.3
189	Beech..............................	1	......	14.7	0.4	0.2	57.9	0.4	1.3	18.0	......
190	Horse chestnut, young, aut'n.	1	6.57	24.2	......	4 0	61.3	7.0	1.1	1.1	1.2
191	Walnut......	1	6 40	11 6	......	10.6	70.1	5.9	0 2	0.7	0.4
192	Elm..................................	1	....	2 2	10.1	3.2	72 7	1.6	0.6	8.9	......
193	Linden	1	....	16.1	5.7	8.0	60.8	4.0	0.8	2.3	1.2
194	Red pine	1	2.81	5.3	4.2	4.7	62 4	2.6	1 0	15.7	0.2
195	White pine......................	1	3.30	8.0	3.2	3.0	69.8	2.5	1.6	8.4	1.0
196	Fir	3	2.01	3.0	1.0	1 4	43.7	8.3	0.8	31.1	0.1

TABLE II.

Composition of Fresh or Air-Dry Agricultural Products, giving the average quantity of water, sulphur, ash, and ash ingredients, in 1,000 parts of substance, by Professor Wolff.

Substance.	*Water.*	*Ash.*	*Potash.*	*Soda.*	*Magnesia.*	*Lime.*	*Phosphoric Acid*	*Sulphuric Acid.*	*Silica.*	*Chlorine.*	*Sulphur.*
I.—HAY.											
Meadow hay	144	66.6	17.1	4.7	3.3	7.7	4.1	3.4	19.7	5.3	1.7
Dead ripe hay	144	66.2	5.0	1.9	2.3	8.5	2.9	0.5	41.8	3.8	2.7
Red clover	160	56.5	19.5	0.9	6.9	19.2	5.6	1.7	1.5	2.1	2.1
White clover	160	60.3	10.6	4.7	6.0	19.4	8.5	5.3	2.7	1.9	2.7
Swedish clover	160	46.5	15.7	0.7	7.1	14.8	4.7	1.9	0.6	1.3	... ..
Lucern	160	60.0	15.2	0.7	3.5	28.8	5.1	3.7	1.2	1.1	2.6
Esparsette	160	45.3	17.9	0.8	2.6	14.6	4.7	1.5	1.8	1.4	... ..
Green vetches	160	73.4	30.9	2.1	5.0	19.3	9.4	2.7	1.3	2.3	1.5
Green oats	145	61.8	24.1	2.0	2.0	4.1	5.1	1.7	20.5	2.5	1.5
II.—GREEN FODDER.											
Meadow grass in blossom	700	23.3	6.0	1.6	1.1	2.7	1.5	1.2	6.9	1.9	0.6
Young grass	800	20.7	11.6	0.4	0.6	2.2	2.2	0.8	2.1	0.4	0.4
Rye grass	700	21.3	5.3	0.9	0.5	1.6	1.7	0.8	8.4	1.1	0.7
Timothy	700	21.0	6.1	0.6	0.8	2.0	2.3	0.8	7.5	1.1	0.8
Other grasses	700	21.8	7.2	0.4	0.6	1.2	1.7	1.0	8.2	0.9	0.7
Oats, beginning to head	820	17.0	7.1	0.8	0.6	1.2	1.4	0.6	4.7	0.8	0.3
" in blossom	770	16.6	6.5	0.6	0.5	1.1	1.4	0.5	5.5	0.7	0.4
Barley, beginning to head	750	22.3	8.6	0.4	0.7	1.6	2.3	0.7	7.0	1.2	0.5
" in blossom	680	22.5	5.9	0.1	0.7	1.4	2.2	0.7	10.8	0.8	0.7
Wheat, beginning to head	7[illegible]0	22.4	7.8	0.4	0.3	1.1	1.7	0.4	9.4	1.2	0.3
" in blossom	690	21.7	5.6	0.1	0.5	0.7	1.6	0.4	12.3	0.6	0.5
Rye fodder	700	16.3	6.3	0.1	0.5	1.2	2.4	0.2	5.2	... ..	... ..
Hungarian millet	680	23.1	8.6	... ..	1.9	2.5	1.3	0.8	6.7	1.5	... ..
Red clover	800	13.4	4.6	0.2	1.6	4.6	1.3	0.4	0.4	0.5	0.5
White clover	810	13.6	2.4	1.1	1.4	4.4	2.0	1.2	0.6	0.4	0.6
Swedish clover	815	10.2	3.5	0.2	1.6	3.2	1.0	0.4	0.1	0.3	... ..
Lucern	753	17.6	4.5	0.2	1.0	8.5	1.5	1.1	0.4	0.3	0.8
Esparsette	785	11.6	4.6	0.2	0.7	3.7	1.2	0.4	0.5	0.3	... ..
Anthyllis vulneraria	780	12.3	1.3	0.5	0.6	8.5	0.9	0.2	0.4	... ..	... ..
Green vetches	820	15.7	6.6	0.5	1.1	4.1	2.0	0.6	0.3	0.5	0.3
" peas	815	13.7	5.6	... ..	1.1	3.9	1.8	0.5	0.4	0.2	... ..
" rape	850	13.5	4.4	0.5	0.6	3.1	1.2	2.2	0.4	1.0	0.6
III.—ROOT CROPS.											
Potato	750	9.4	5.6	0.1	0.4	0.2	1.8	0.6	0.2	0.3	0.2
Artichoke	800	10.3	6.7	... ..	0.3	0.4	1.6	0.3	... ..	0.2	... ..
Beet	883	8.0	4.3	1.2	0.4	0.4	0.8	0.3	0.2	0.5	0.1
Sugar beet	816	8.0	4.0	0.8	0.7	0.5	1.1	0.4	0.3	0.2	... ..
Turnip	909	7.5	3.0	0.8	0.3	0.8	1.0	1.1	0.2	0.3	0.4

Com osition of Fresh or Air-Dry Agricultural Products.

Substance.	*Water.*	*Ash.*	*Potash.*	*Soda.*	*Magnesia.*	*Lime.*	*Phosphoric Acid.*	*Sulphuric Acid.*	*Silica.*	*Chlorine.*	*Sulphur.*
III.—ROOT CROPS.											
White turnip*	915	6.1	3.1	0.2	0.1	0.8	1.1	0.4	0.1	0.4	......
Kohl rabi	877	9.5	4.9	0.6	0.2	0.9	1.4	0.8	0.1	0.5	......
Carrot	860	8.8	3.2	1.9	0.5	0.9	1.1	0.6	0.2	0.3	0.1
Sugar beet heads†	840	6.5	1.9	1.6	0.7	0.6	0.8	0.5	0.1	0.1	......
Chicory	800	10.4	4.2	0.8	0.7	0.9	1.5	1.0	0.6	0.4	......
IV.—LEAVES AND STEMS OF ROOT CROPS.											
Potato tops end of August	825	15.6	2.3	0.4	2.6	5.1	1.0	0.9	1.2	0.7	0.6
" first of October	770	11.8	0.7	0.1	2.7	5.5	0.6	0.6	0.5	0.4	0.5
Beet tops	907	14.8	4.3	3.1	1.4	1.7	0.8	1.1	0.7	1.7	0.5
Sugar beet tops	897	18.0	4.0	3.0	3.3	3.6	1.3	1.4	0.6	1.0	......
Turnip tops	898	14.0	3.2	1.1	0.6	4.5	1.3	1.4	0.5	1.2	0.5
Kohl rabi tops	850	25.3	3.6	1.0	1.0	8.4	2.6	3.0	2.6	1.0	......
Carrot tops	808	26.1	3.7	6.0	1.2	8.6	1.2	2.1	1.5	1.9	1.4
Chicory tops	850	18.7	11.2	0.1	0.6	2.7	1.7	1.7	0.2	0.3	......
Cabbage heads	885	12.4	6.0	0.5	0.4	1.9	2.0	1.1	0.1	0.3	0.5
Cabbage stems	820	11.6	5.1	0.6	0.5	1.3	2.4	0.9	0.2	0.1	......
V.—MANUFACTURED PRODUCTS AND REFUSE.											
Sugar beet cake	692	9.7	3.6	0.8	0.5	2.5	1.0	0.4	0.6	0.5	... ..
a. Common cake. [machine	692	9.3	2.3	1.2	......	2.5	1.2	0.5	... ..	1.2	... ..
b. Residue from Centrifugal	820	5.6	2.6	0.5	......	1.4	0.7	0.4	... ..	... ..	... ..
c. Residue of maceration	885	4.1	1.5	0.4	0.5	1.1	0.3	0.1	... ..	0.1	... ..
Beet molasses	175	93.1	66.2	9.8	0.4	5.6	0.6	2.0	0.6	9.4	... ..
Molasses slump*	907	17.7	15.9		0.2		... ..	0.3	.. ...	0.3	... ..
Raw beet sugar	43	13.7	4.6	3.8	......	1.2	.. ...	3.1	0.1	0.8	... ..
Potato slump*	947	5.9	2.7	0.4	0.5	0.4	1.2	0.4	0.2	0.1	... ..
Potato fibre†	806	1.9	0.3	......	0.1	0.9	0.5	.. ...	0.1	... ..	... ..
Potato skins‡	300	67.1	48.3	0.5	4.5	6.4	2.3	0.3	1.8	1.4	... ..
Fine wheat flour	136	4.1	1.5	0.1	0.3	0.1	2.1	... ..	... ..	... ..	... ..
Rye flour	142	16.9	6.5	0.3	1.4	0.2	8.5	... ..	... ..	.. ..	.. ..
Barley flour	140	20.0	5.8	0.5	2.7	0.6	9.5	0.6	... ..	... ..	... ..
Barley dust‖	113	49.8	9.4	0.7	3.8	1.2	14.4	... ..	9.9	... ..	... ..
Maize meal	140	9.5	2.7	0.3	1.4	0.6	4.3	... ..	... ..	... ..	... ..
Millet meal	140	11.6	2.3	0.3	3.0	......	5.5	0.3	... ..	... ..	... ..
Buckwheat grits	140	6.2	1.6	0.4	0.8	0.1	3.0	0.1	... ..	0.1	... ..
Wheat bran	135	55.6	13.3	0.3	9.4	2.6	28.8	... ..	0.6	... ..	... ..
Rye bran	131	71.4	19.3	0.9	11.3	2.5	34.2	... ..	... ..	... ..	... ..
Brewer's grains	768	12.0	0.5	0.1	1.2	1.4	4.6	0.1	3.9	... ..	... ..
Malt	475	14.6	2.5	......	1.2	0.5	5.3	... ..	4.8	... ..	... ..
Dried malt	42	26.6	4.6	......	2.2	1.0	0.7	... ..	8.8	... ..	... ..
Malt sprouts	92	59.6	20.8	......	0.8	0.9	12.5	3.8	17.7	... ..	... ..
Wine grounds	650	16.1	8.6	0.1	0.5	2.5	2.5	1.2	... ..	0.1	... ..
Grape skins	600	16.2	8.0	0.4	1.0	2.1	3.4	0.7	0.6	0.1	.. ..
Beer	900	3.9	1.5	0.3	0.2	0.1	1.3	0.1	0.4	0.1	... ..
Wine	866	2.8	1.8	......	0.2	0.2	0.5	0.1	0.1	......	... ..

*No special variety. †Crowns of sugar beet roots. *Residue from spirit manufacture. †Refuse of starch manufacture. ‡From boiled potatoes. ‖Refuse from making barley grits.

COMPOSITION OF FRESH OR AIR-DRY AGRICULTURAL PRODUCTS,

Substance.	*Water.*	*Ash.*	*Potash.*	*Soda.*	*Magnesia.*	*Lime.*	*Phosphoric Acid.*	*Sulphuric Acid*	*Silica.*	*Chlorine.*	*Sulphur.*
V.—MANUFACTURED PRODUCTS AND REFUSE.											
Rape cake.........	150	56.0	13 6	0.1	6 4	6.1	20 7	1.9	4.9	0 1	.....
Linseed cake...	115	55.2	12.9	0 8	8.8	4.7	19 4	1.9	3.6	0.3	.....
Poppy cake	100	95.4	19.8	4.3	4.1	26.8	36.1	1.9	4 6	... ..	...
Walnut cake...	136	46.4	15.4	......	5.7	3.1	20.3	0.5	0.7	0.1	.....
Cotton seed cake..	115	61.5	21.8	......	2 6	2.8	29 5	0.7	2.5	......	.....
VI—STRAW.											
Winter wheat.............	141	42.6	4.9	1 2	1.1	2.6	2.3	1.2	28.2	... ..	1 6
Winter rye..................	154	40.7	7.6	1.3	1.3	3 1	1.9	0.8	23.7	... ..	0.9
Winter spelt................	143	47.7	5.3	0,2	0.4	2.3	3.0	0.9	34.1	... ..	... ..
Summer rye.................	143	47.6	11.1	......	1.3	4.4	3.1	1 2	26 6	.. ..	... ..
Barley	140	43 9	9.3	2.0	1.1	3.3	1 9	1.6	23.6	... ..	1.3
Oats.........................	141	44.0	9 7	2.3	1.8	3 6	1.8	1.5	21.2	... ..	1.7
Maize	140	47.2	16 6	0 5	2.6	5.0	3 8	2.5	17.9	... ..	3 9
Peas.........................	143	49.2	10.7	2.6	3.8	18 6	3.8	2 8	2 8	3.0	0.7
Field bean......	180	58.4	25 9	2.2	4.6	13.5	4.1	0.1	3.1	8.1	2.2
Garden bean	150	51.5	19.1	3.1	2.7	14 1	4 1	1.8	2 4	2.7	2.1
Buckwheat	160	51.7	24.1	1 1	1.9	9.5	6.1	2.7	2.8	4 0	.. ...
Rape...........	170	38.0	9.7	3.9	2.1	10.1	2.7	2.7	2.6	4 7	1.4
Poppy...	160	66 0	25.1	0.9	4.3	19.9	2.3	3 4	7.5	1.7	... ..
VII.—CHAFF.											
Wheat......	138	92.5	8.4	1 7	1.2	1.9	4.0	.. ...	75 1	... ..	0.8
Spelt......	130	82.7	7.9	0.2	2.1	2 0	6.0	1 9	61 4	... ..	... ..
Barley......	140	122.4	9.4	1 1	1.6	12.7	2.4	3.7	86.7	... ..	... ..
Oats......	143	79.0	10.4	3.8	2.1	7.0	0.2	2.0	47.3	... ..	... ..
Maize cobs.........	115	5.0	2.4	0.1	0.2	0.2	0.2	0.1	1.3	0.2	1.3
Flax seed hulls...........	120	58.3	18.1	2.5	1 6	17.2	1.6	2.8	10.0	3.6	1.8
VIII.—TEXTILE PLANTS, ETC.											
Flax straw.................	140	31.9	11.8	1.6	2.3	8.3	4.3	2.0	2 2	1.5	1.4
Rotted flax stems.........	100	21 6	1.9	1.0	1.2	11.1	1.3	0.7	3.0	... ..	0.2
Flax fiber	100	6 0	0 2	0 2	0 3	3.8	0.7	0.2	0 3	... ..	... ..
Entire flax plant.....	250	32.3	11 3	1 5	2.9	5.0	7.4	1.6	0 8	1.9	... ..
Entire hemp plant	300	28.2	5.2	0.9	2.7	12.2	3.3	0.8	2.1	0.7	... ..
Entire hop plant............	250	74.0	19.4	2.8	4 3	11.8	9.0	3.8	15.9	3.4	2.0
Hops.........	220	59.8	22.3	1.3	2.1	10 1	9.0	1.6	9.2	0.2	4.8
Tobacco.....................	180	197.5	54.1	7.3	20.7	73.1	7.1	7.7	19.0	8 8	... ..
IX.—LITTER.											
Heath	200	36.1	4.8	1 9	3.0	6.8	1.8	1.6	12.7	0.8	... ..
Broom (*Spartium*).........	160	18.9	6.9	0.5	2.8	3.2	1.6	0.7	1.9	0.5	... ..
Fern (*Aspidium*)...........	160	58.9	25.2	2.7	4.5	8.3	5.7	3.0	3.6	6.0	.. ..
Scouring rush (*Equisetum*)	140	204 4	27.0	1.0	4.7	25.6	4.1	12.9	110.0	11.7	... ..
Sea weed (*Fucus*).........	180	118.0	17.1	28.3	11.2	16.4	3.7	28,3	2.0	11.9	... ..
Beech leaves	150	57.4	3.0	0.3	3.4	25.8	2.4	2.1	19.5	0.2	... ..
Oak leaves.................	150	41.7	1.5	0.2	1.7	20.2	3.4	1.8	12.9	... ..	... ..
Fir leaves (*Pinus sylvestris*)	160	11.8	1.2	.. ...	1.1	4.9	1.9	0.5	1.5	0.5	... ..
Red pineleaves(*Pinus picea*	160	48.9	0.7	... ..	1.1	7.4	4.0	1.4	34.3	... ...	... ..
Reed (*Arundo phrag*).....	180	38.5	3.3	0.1	0.5	2.3	0.8	1.1	27.5	... ..	... ..
Sedge (*Carex*)..............	140	69.5	23.1	5.1	2.9	3.7	4.7	2.3	21.8	3.9	... ..
Rush (*Juncus*)......	140	45.6	16.7	3.0	2.9	4.3	2.9	4.0	5.0	6.5	... ..
Bulrush (*Scirpus*)...........	140	74.4	7.2	7.7	2.2	5.4	4.8	4.2	32.2	3.9	... ..

COMPOSITION OF FRESH OR AIR-DRY AGRICULTURAL PRODUCTS.

Substance.	*Water.*	*Ash.*	*Potash.*	*Soda.*	*Magnesia.*	*Lime.*	*Phosphoric Acid.*	*Sulphuric Acid.*	*Silica.*	*Chlorine.*	*Sulphur.*
X.—GRAINS AND SEEDS OF AGRICULTURAL PLANTS.											
Wheat	143	17,7	5,5	0,6	2,2	0,6	8,2	0.4	0,3	... ..	1,5
Rye	149	17,3	5,4	0,3	1,9	0,5	8 2	0.4	0,3	... ..	1,7
Barley	145	21,8	4.8	0,6	1,8	0,5	7,2	0,5	5,9	... ..	1,4
Oats	140	26 4	4,2	1,0	1,8	1,0	5,5	0,4	12,3	... ..	1,7
Spelt, with husk	148	35,8	6,2	0,6	2,1	0,9	7,2	0,6	15,8	... ..	... ..
Maize	136	12 3	3,3	0,2	1,8	0,3	5.5	0.1	0,3	... ..	1,2
Rice, with husk	120	69,0	12,7	3,1	5,9	3,5	32,6	0,4	0,4	... ..	... ..
" husked	130	3.4	0,8	0.2	0,5	0,1	1,7	... ..	0,1	... ..	... ..
Millet, with husk	130	39,1	4,7	0,4	3,3	0,4	9,1	0,1	20,5	... ..	1,8
" husked	131	12,3	2,3	0,7	2,3	... ..	6,6	0,2	... ..	... ..	... ..
Sorghum	140	16,0	4.2	0.5	2,4	0,2	8,1	... ..	1,2	... ..	... ..
Buckwheat	141	9.2	2,1	0,6	1,2	0,3	4,4	0,2	... ..	0,2	... ..
Rape seed	120	37,3	8,8	0,4	4,6	5 2	16,4	1,3	0,4	0,1	8,2
Flax "	118	32,2	10,4	0,6	4.2	2,7	13,0	0,4	0,4	... ..	1,7
Hemp "	122	48,1	9,7	0,4	2,7	11,3	17,5	0,1	5,7	0,1	... ..
Poppy "	147	52,2	7,1	0,5	5.0	18,5	16,4	1,0	1,7	2 3	... ..
Mustard "	120	37.8	6,0	2,2	3,9	7,1	14,7	1,8	0,9	0,2	10,1
Beet "	140	48,7	9,1	8,4	9,2	7,6	7.6	2,0	1,0	4.6	0,8
Turnip "	120	35,0	7,7	0,3	3,0	6,1	14,1	2,5	0,2	... ..	7,8
Carrot "	120	74 8	14,3	3,6	5,0	29,0	11,8	4.2	4,0	2,5	2.7
Peas	138	24,2	9,8	0,9	1,9	1,2	8,8	0,8	0,2	0,6	2,4
Vetches	136	20,7	6,3	2,2	1,8	0,6	7,9	0,9	0,4	0,2	... ..
Field beans	141	29,6	12,0	0,4	2,0	1,5	11,6	1,5	0,4	0,8	2,3
Garden beans	148	26,1	11,5	0,8	2,0	2,0	7,9	1,0	0,2	0,3	2 5
Lentils	134	17,8	7,7	1,8	0,4	0,9	5,2	... ..	0,2	0,6	... ..
Lupines	138	34,0	11,4	6,0	2,1	2,7	8,7	2,3	0,3	0,6	... ..
Clover seed	150	36,9	13.8	0,2	4,5	2,3	12,4	1,7	0,9	0,5	.....
Esparsette seed	160	37,6	10,8	1,1	2,5	11,9	9,0	1,2	0,3	0,4	2,8
XI.—FRUITS AND SEEDS OF TREES, ETC.											
Grape seeds	120	24,7	7,1	... ..	2,1	8,4	5.9	0,6	0,3	0,1	... ..
Alder "	140	44,2	16,6	0,7	3,5	13,6	5,7	1,5	1,4	... ..	... ..
Beech nuts	180	27,1	6,2	2,7	3,1	6,7	5,6	0,6	0,5	0,1	... ..
Acorns, fresh	560	9,6	6,2	0,1	0,5	0,7	1,6	0,2	0,2	0,1	... ..
" dried	158	18,3	11,8	0,1	1,0	1,3	3,3	0,5	0,4	0,3	... ..
Horse chestnuts, fresh	492	12,0	7,1	... ..	0,1	1,4	2,7	0,2	... ..	0,8	... ..
" " green husk	818	8,0	6,1	... ..	0,1	0,8	0,5	0,1	0,1	0,4	... ..
Apple, entire fruit	840	2,7	1,0	0,7	0,2	0,1	0,4	0,2	0,1	... ..	... ..
Pear, " "	800	4,1	2,2	0,4	0,2	0,3	0,6	0.2	0,1	... ..	... ..
Cherry, " "	780	4,3	2,2	0,1	0,2	0,3	0,7	0,2	0,4	0,1	... ..
Plum, " "	820	4,0	2,4	... ..	0,2	0,4	0,6	0,2	0,1	... ..	... ..
XII.—LEAVES OF TREES.											
Mulberry	670	11,7	2,3	... ..	0,6	3,0	1,2	0,1	4,1	... ..	... ..
Horse chestnuts, spring	700	21,5	8,3	... ..	0,8	4,6	5,0	1.3	0,6	0,8	... ..
" " autumn	600	30,1	5,9	... ..	2,4	12,2	2,5	0,5	4,2	1,2	... ..
Walnut, spring	700	23.2	9,9	... ..	1,1	6,2	4,9	0,6	0,3	0,1	... ..
" autumn	600	28,4	7,6	... ..	2,8	15,3	1,1	0,8	0,6	0,2	... ..
Beech, summer	750	12,1	2,2	0,2	1,1	4,4	0,9	0,4	1,8	0,1	... ..
" autumn	550	30,5	1,6	0,2	1,8	13,7	1,3	1,1	10,3	0,1	... ..
Oak, summer	700	13,8	4,6	... ..	1,9	3,6	1,7	0,4	0,6	... ..	... ..
" autumn	600	19,6	0,7	0,1	0,8	9,5	1,6	0,9	6,1	... ..	... ..

COMPOSITION OF FRESH OR AIR-DRY AGRICULTURAL PRODUCTS.

Substance.	*Water.*	*Ash.*	*Potash.*	*Soda.*	*Magnesia.*	*Lime.*	*Phosphoric Acid.*	*Sulphuric Acid.*	*Silica.*	*Chlorine.*	*Sulphur.*
XII.—LEAVES OF TREES.											
Fir, autumn	550	6,3	0,6	... ..	0,6	2,6	1,3	0,3	0,8	0,3	... ..
Red pine, autumn	550	26,2	0,4	... ..	0,6	4,0	2,1	0,7	8,41	... ..	... ..
XIII.—WOOD, AIR-DRY.											
Grape	150	23,4	7,0	1,6	1,6	8,7	3,0	0,6	0,2	0,2	... ..
Mulberry	150	13.7	0,9	2,0	0,8	7,8	0,3	1,4	0,5	0,6	... ..
Birch	150	2,6	0,3	0,2	0,2	1,5	0,2	... ..	0,1	... ..	... ..
Beech, body wood	150	5,5	0,9	0,2	0,6	3,1	0,3	0,1	0,3	... ..	... ..
" small wood	150	8,9	1,4	0,2	1,5	4,1	1,0	0,1	0,6	... ..	... ..
" brush	150	12,3	1,7	0 3	1,3	5.9	1,5	0,1	1,2	... ..	... ..
Oak, body wood	150	5,1	0,5	0,2	0,2	3,7	0,3	0,1	0,1	... ..	... ..
" small branches with bark	150	10,2	2,0	... ..	0,8	5,5	0,9	0,2	0,3	... ..	... ..
Horse chestnut, young wood in autumn	150	28,1	5,5	... ..	1,5	14.3	5.9	... ..	0,2	0,4	... ..
Walnut	150	25,5	3,9	... ..	2,0	14,2	3,1	0,8	0,7	0,1	... ..
Apple tree	150	11,0	1,3	0,2	0,6	7,8	0,5	0,3	0,2	... ..	... ..
Red pine	150	2,1	0,1	0,6	0,1	1,0	0,1	0,1	0,1	... ..	... ..
White pine	150	2,4	0,4	0,2	0,1	1,2	0,1	0,1	0,2	... ..	... ..
Fir	150	2,6	0,3	0,1	0,2	1,3	0,2	0,1	0,4	... ..	... ..
Larch	150	2,7	0,4	0,2	0,7	0,7	0,1	0,1	0,1	... ..	... ..
XIV.—BARK.											
Birch	150	11,3	0,4	0,6	0,9	5,2	0,8	0,2	2,3	0,2	... ..
Horse chestnut, young in autumn	150	55,9	13,5	... ..	2,2	34,3	3,9	0,6	0,6	0,7	... ..
Walnut, young in autumn	150	54,4	6,3	... ..	5,8	38,1	3,2	0,1	0,4	0,2	... ..
Red pine	150	23,9	1,3	1,0	1,1	14,9	0,6	0,2	3.8	0,1	... ..
White pine	150	28,1	2,3	0,9	0,8	19,6	0,7	0,5	2,3	0,3	... ..
Fir	150	17,1	0,5	0,2	0,2	7,5	1,4	0,1	5,3	.. ..	... ..

TABLE III.

Proximate Composition of Agricultural Plants and Products, giving the average quantities of Water, Organic Matter, Ash, Albuminoids, Carbohydrates, etc., Crude Fiber, Fat, etc., by Professors Wolff and Knop.*

Substance.	*Water.*	*Organic Matter.*†	*Ash.*	*Albuminoids.*	*Carbohydrates, etc.*‖	*Crude Fiber.*‡	*Fat, etc.*¶
HAY.							
Meadow hay, medium quality	14.3	79.5	6.2	8.2	41.3	30.0	2.0
Aftermath	14.3	79.2	6.5	9.5	45.7	24.0	2.4
Red clover, full blossom	16.7	77.1	6.2	13.4	29.9	35.8	3.2
" " ripe	16.7	77.7	5.6	9.4	20.3	48.0	2.0
White clover, full blossom	16.7	74.8	8.5	14.9	34.3	25.6	3.5
Swedish or Alsike clover (*Trifolium hybridum*)	16.7	75.0	8.3	15.3	29.2	30.5	3.3
" clover, ripe	16.7	78.3	5.0	10.2	23.1	45.0	2.2
Lucern, young	16.7	74.6	8.7	19.7	32.9	22.0	3.3
" in blossom	16.7	76.9	6.4	14.4	22.5	40.0	2.5
Sand lucern, early blossom (*Medicago intermedia*)	16.7	77.2	6.1	15.2	26.9	35.1	3.0
Esparsette, in blossom	16.7	77.1	6.2	13.3	36.7	27.1	2.5
Incarnate clover, " (*Trifolium incarnatum*)	16.7	76.1	7.2	12.2	30.1	33.8	3.0
Yellow " " (*Medicago lupulina*)	16.7	77.3	6.0	14.6	36.5	26.2	3.3
Vetches, in blossom	16.7	75.0	8.3	14.2	35.3	25.5	2.5
Peas, "	16.7	76.3	7.0	14.3	36.8	25.2	2.6
Field spurry, in blossom (*Spergula arvensis*)	16.7	73.8	9.5	12.0	39.8	22.0	3.2
" " after blossom	16.7	75.5	7.8	7.8	41.7	26.0	2.5
Serradella, " " (*Ornithopus sativus*)	16.7	77.7	5.6	14.6	29.2	33.9	1.5
" before "	16.7	75.8	7.5	15.3	37.2	26.1	1.9
Cut in blossom.							
Italian Rye grass (*Lolium italicum*)	14.3	77.9	7.8	8.7	51.4	16.9	2.8
Timothy (*Pheleum pratense*)	14.3	81.2	4.5	9.7	48.8	22.7	3.0
Early meadow grass (*Poa annua*)	14.3	83.3	2.4	10.1	47.2	25.9	2.9
Crested dog's tail (*Cynosurus cristatus*)	14.3	80.2	5.5	9.5	48.0	22.6	2.8
Soft broom grass (*Bromus mollis*)	14.3	80.7	5.0	14.8	35.0	31.0	1.8
Orchard grass (*Dactylis glomerata*)	14.3	81.1	4.6	11.6	40.7	28.9	2.7
Barley grass (*Hordeum pratense*)	14.3	80.4	5.3	9.6	42.0	27.2	2.0
Meadow foxtail (*Alopecurus pratensis*)	14.3	79.0	6.7	10.6	39.5	29.0	2.5
Oat grass, French rye grass (*Arrhenatherum avenaceum*)	14.3	75.8	9.9	11.1	35.3	29.4	2.7
English rye grass (*Lolium perenne*)	14.3	79.2	6.5	10.2	38.9	30.2	2.7
Harter Schwingel (*Festuca?*)	14.3	81.0	4.7	10.4	37.5	33.2	2.9
Sweet-scented vernal grass (*Anthoxanthum odoratum*)	14.3	80.3	5.4	8.9	40.2	31.2	2.9

* *Landwirthschaftlicher Kalender*, 1867, through Knop's *Agricultur-Chemie*, 1868, pp 715–720. This Table is, as regards water and ash, a repetition of Table II, but includes the newer analyses of 1865–7. Therefore the averages of water and ash do not in all cases agree with those of the former Tables. It gives besides, the proportions of nitrogenous and non-nitrogenous compounds, *i. e.*, Albuminoids and Carbohydrates, etc. It also states the averages of Crude Fiber and of Fat, etc. The discussion of the data of this Table belongs to the subjects of Food and Cattle-Feeding. They are, however, inserted here, as it is believed they are not to be found elsewhere in the English language. † *Organic Matter* here signifies the combustible part of the plant. ‖ *Carbohydrates, etc.*, includes fat, starch, sugar, pectin, etc., all in fact of *Org. Matter*, except Albuminoids and Crude Fiber. ‡ *Crude Fiber* is impure cellulose obtained by the processes described on pages 60 and 61. ¶ *Fat, etc*, is the ether-extract, p. 94, and contains besides fat, wax, chlorophyll, and in some cases resins.

PROXIMATE COMPOSITION OF AGRICULTURAL PLANTS AND PRODUCTS.

Substance.		*Water.*	*Organic Matter.*	*Ash.*	*Albuminoids.*	*Carbohydrates, etc.*	*Crude Fiber.*	*Fat, etc.*
HAY.								
Velvet grass (*Holcus lanatus*)	Cut in blossom.	14,3	80,2	5,5	9,9	36,7	33,6	3,1
Spear grass Kentucky Blue grass (*Poa pratensis*)		14,3	80,6	5,1	8,9	39,1	32,6	2,3
Rough meadow grass (*Poa trivialis*)		14,3	78,6	7,1	8,4	37,6	32,6	3,2
Yellow oat grass (*Avena flavescens*)		14,3	79,8	5,9	6,4	42,6	30,8	2,2
Quaking grass (*Briza media*)		14,3	78,3	7,4	5,2	42,8	30,3	2,6
Average of all the grasses		14,3	79,9	5,8	9,5	41,7	38,7	2,6
STRAW.								
Winter wheat		14,3	80,2	5,5	1,0	30,2	48,0	1 5
Winter rye		14,3	82,5	3,2	1,5	27,0	54,0	1,3
Winter spelt		14,3	79,7	6,0	2,0	27,7	50,5	1,4
Winter barley		14,3	80,2	5,5	2,0	29,8	48,4	1,4
Summer barley		14,3	78,7	7,0	3,0	32,7	43,0	1,4
" " with clover		14,3	77,7	8,0	6,0	34,7	37,5	1,7
Oat		14,3	80,7	5,0	2,5	38,2	40,0	2,0
Vetch fodder		14,3	79,7	6,0	7,5	28,2	44,0	2,0
Pea		14,3	81,7	4,0	6,5	35,2	40,0	2,0
Bean		17,3	77,7	5,0	10,2	33,5	34,0	1,0
Lentil		14,3	79,2	6,5	14,0	27,2	36,6	2,0
Lupine		14,2	81,4	4,4	4,9	34,7	41,8	1,5
Maize		14,0	82,9	4,0	3,0	39,0	40,0	1,1
CHAFF AND HULLS.								
Wheat		14,3	73,7	12,0	4,5	33,2	36,0	1,4
Spelt		14,3	77,2	8,5	2,9	32,8	41,5	1,3
Rye		14,3	78,2	7,5	3,5	28,2	46,5	1,2
Barley		14,3	72,7	13 0	3,0	38,7	30,0	1,5
Oat		14,3	67,7	18,0	4,0	29,7	34,0	1,5
Vetch		15,0	77,0	8,0	8,5	32,5	36,0	2,0
Pea		14,3	79,7	6,0	8,1	36,6	35,0	2,0
Bean		15,0	77,0	8,0	10,5	29,5	37,0	2,0
Lupine		14,3	82 9	2,8	2,5	47,2	33,0	2,5
Rape		10,3	77,5	8,5	3,5	40,0	34,0	1,6
Maize cobs		10,3	83,2	2,8	1,4	44,0	37,8	1,4
GREEN FODDER.								
Grass, before blossom		75,0	22,9	2,1	3,0	12,9	7,0	0,8
" after "		69,0	29,0	2,0	2,5	15,0	11,5	0,7
Red clover, before "		83,0	15,5	1,5	3,3	7,7	4 5	0,7
" " full "		78,0	20,3	1,7	3,7	8 6	8,0	0,8
White " " "		80,5	17,5	2,0	3,5	8,0	6,0	0,8
Swedish clover, early blossom		85,0	13,5	1,5	3,3	5,7	4,5	0,6
" " full "		82,0	16,2	1,8	3,3	6,3	6 6	0,6
Lucern, very young		81,0	17,3	1,7	4,5	7,8	5,0	0,6
" in blossom		74,0	24,0	2,0	4,5	7,0	12,5	0,7
Sand lucern, early blossom		78,0	20,1	1,9	4,0	6,6	9,5	0,8
Esparsette, in "		80,9	18,5	1,5	3,2	8,8	6,5	0,6
Incarnate clover, in " (*Trifolium incarnatum*)		81,5	16,9	1,6	2,7	6,7	7,5	0,6
Yellow clover, in blossom (*Medicago lupulina*)		80,0	18,5	1,5	3,5	9,0	6,0	0,8
Serradella, " " (*Ornithopus sativus*)		80,0	18,7	1,3	3,6	7,0	8,1	0,4

Proximate Composition of Agricultural Plants and Products.

Substance.	*Water.*	*Organic Matter.*	*Ash.*	*Albuminoids.*	*Carbohydrates, etc.*	*Crude Fiber.*	*Fat, etc.*
GREEN FODDER.							
Vetches, in blossom	82 0	16,2	1,8	3,1	7,6	5,5	0,6
Peas, " "	81,5	17,0	1,5	3,2	8,2	5.6	0,6
Oats, early blossom	81,0	17,6	1,4	2,3	8,8	6,5	0,5
Rye	72,9	25.5	1,6	3,3	14,9	7,3	0,9
Maize, late end August	84,3	14,6	1,1	0,9	8,7	5,0	0,5
" early " "	82,2	16,7	1,1	1,1	10,9	4,7	0,5
Hungarian millet, in blos'm (*Panicum germanicum*)	65,6	32,0	2,4	5,9	15,0	11,5	1,5
Sorghum saccharatum	74 0	25,1	0,9	2,5	15,3	7,3	1,4
Sorghum vulgare	77,3	21,6	1,1	2,9	11,9	6,7	?
Field spurry, in blossom	80,0	18,0	2,0	2,3	10,4	5,3	0,7
Cabbage	89,0	9,8	1,2	1,5	6,3	2,0	0,4
" stumps	82,0	16,1	1,9	1,1	12,2	2,8	0,8
Field beet leaves	90,5	6,7	1,8	1,9	4,6	1,3	0,5
Carrot leaves	82,2	14,2	3,6	3,2	8,0	3,0	1,0
Poplar and elm leaves	70 0	28,0	2,0	6,0	15,5	6,5	1,5
Artichoke stem	80,0	17,3	2,7	2,3	10,6	3,4	0,8
Rape leaves	dry	75,5	44,5	20,0	47,5	8,0	2,0
ROOTS AND TUBERS.							
Potato	95,0	24,1	0,9	2,0	21,0	1,1	0.3
Jerusalem Artichoke	80,0	18,9	1.1	2,0	15,6	1,3	0,5
Turnip Chervil ? (Koerbelrübe)	76,0	23,1	0,9	3,2	17,0	1,0	0,6
Kohl-rabi	88,0	10,8	1,2	2,3	7,3	1,2	0,2
Field beets (about 3 lbs. weight)	88,0	11,1	0.9	1,1	9,1	0,9	0,1
Sugar beets (1-2 lbs)	81,5	17,7	0,8	1,0	15,4	1,3	0,1
Ruta-bagas (about 3 lbs.)	87,0	12,0	1,0	1,6	9,3	1,1	0,1
Carrot (about ½ lb.)	85,0	14.0	1,0	1,5	10,8	1,7	0,2
Giant carrot (1-2 lbs.)	87,0	12,2	0 8	1,2	9,8	1,2	0,2
Turnips (Stoppelrübe)	91 5	7,7	0,8	0,8	5,9	1,0	0.1
Turnips (Turnipsrübe)	92.0	7,2	0,8	1,1	5,1	1,0	0 1
Parsnip	88,3	11,0	0.7	1,6	8,4	1,0	0,2
Pumpkin	94 5	4,5	1,0	1,3	2,8	1,0	0,1
GRAINS AND SEEDS.							
Rice	14,6	84.9	0,5	7.5	76,5	0,9	0,5
Winter wheat	14,4	83.6	2,0	13,0	67,6	3,0	1,5
Wheat flour	12 6	86,7	0,7	11,8	74.1	0,7	1,2
Spelt	14.8	81,3	3 9	10,0	54,8	16,5	1,5
Winter rye	14 3	83,7	2,0	11,0	69,2	3,5	2,0
Rye flour	14,0	84 4	1,6	10,5	72,5	1,5	1,6
Winter barley	14.3	83,4	2,3	9,0	65,9	8,5	2,5
Summer barley	14,3	83.1	2,6	9,5	66,6	7,0	2,5
Oats	14,3	82,7	3,0	12,0	60,9	10,3	6,0
Maize	14.4	83 5	2,1	10,0	68,0	5 5	7.0
Millet	14,0	83 0	3,0	14,5	62 1	6.4	3,0
Buckwheat	14,0	83,6	2,4	9,0	59.6	15,0	2,5
Vetches	14 3	83.4	2,3	27,5	49,2	6.7	2,7
Peas	14,3	83,2	2,5	22,4	52,3	9,2	2,5
Beans (field)	14,5	82,0	3,5	25 5	45,5	11,5	2,0
Lentils	14,5	82,5	3.0	23,8	52,0	6,9	2,6

PROXIMATE COMPOSITION OF AGRICULTURAL PLANTS AND PRODUCTS.

Substance.	*Water.*	*Organic Matter.*	*Ash.*	*Albuminoids.*	*Carbohydrates, etc.*	*Crude Fiber.*	*Fat etc.*
GRAINS AND SEEDS.							
Lupines	14,5	82,0	3,5	34,5	33,0	14 5	6,0
Acorns, without shell, dry	20,0	78,4	1,6	5,0	68,8	4,6	4,3
" with " fresh	56,0	43,0	1,0	2,0	36,5	4,5	2,3
Chestnuts, without shell, fresh	49,2	49,0	1,8	3,0	45,2	0,8	2,5
Madia seed	8,4	86,9	4,7	22,9	46,0	18,0	41 0
Flax seed	12,3	82,7	5,0	20,5	55,0	7,2	37,0
Rape seed	11,0	85,1	3,9	19,4	55,4	10,3	40,0
Hemp seed	12.2	83,6	4,2	16,3	55,2	12,1	33,6
Poppy seed	14,7	78,3	7,0	17,5	54,7	6,1	41,0
Horse chestnut	30,0	68,8	1,2	10,5	58,3	4,0	23 0
REFUSE.							
Sugar beet cake	70,0	26,6	3,4	1,8	18,5	6,3	0,2
" " " residue from centrifugal machine	82,0	16,8	1,2	1,0	12,2	3,6	0,1
" " " " " maceration	92,6	6,6	0,8	0,8	4,4	1,4	0,1
Potato slum	94,8	4,6	0,6	1,0	3,0	0,6	0,1
Rye slum	89,0	10,5	0,5	2,1	6,8	1,6	0,4
Maise slum	89,0	10,5	0,5	2,0	7,2	1,3	1,2
Molasses slum	92,0	6 3	1,7	1,2	5,1	.....	.....
Brewer's grains	76,6	22,2	1,2	4,9	11,1	6,2	1,6
Malt sprouts	8,0	85,2	6,8	23,0	44,7	17,5	2,5
Fresh malt, with sprouts	47,5	50,8	1,7	6,5	39,5	4,3	1,5
Dry malt, without sprouts	4,2	93,1	2,7	8,8	76,3	8,0	2,5
Wheat bran	13,1	81,8	5,1	14,0	50,0	17,8	3,8
Rye bran	12,5	83,0	4,5	14,5	53,5	15,0	3,5
Rape cake	15 0	77,6	7,4	28,3	33,5	15,8	9,0
Linseed cake	11,5	80,6	7,9	28,3	41,3	11,0	10,0
Gold of pleasure cake	15,0	78,1	6,9	28,5	37,1	12,5	8,5
Poppy cake	10,0	81,6	8,4	32,5	37,7	11,4	8,1
Hemp cake	10,5	85,5	4,0	27,0	36,5	22,0	6,2
Beechnut cake	10,0	84 8	5,2	24,0	31,3	20,5	7,5
" " without shells	12,5	79,8	7,7	37,3	36,9	5,5	7,5
Beet molasses	16,7	72,5	10,8	8,0	64,5	......	......
Potato fiber	82,6	71,1	0,3	0,8	15,0	1,3	0,1
COFFEE. TEA.							
Coffee bean	12,0	93,0	7,0	10,0	49,0	34,0	12,0
Chocolate bean	11,0	85,0	4,0	20,0	52,0	13,0	44,0
Black China tea	15,0	79,0	6,0	5,0	32,0	40,0	2,9
Green " "	15 0	79,0	6,0	5,0	27,0	45,0	2,0

TABLE IV.

DETAILED ANALYSES OF BREAD GRAINS.

	Albuminoids.	*Starch.*	*Gum and Sugar.*	*Fat.*	*Bran and Crude Fiber.*	*Ash.*	*Water.*	*Analyst.*
WHEAT.								
From Elsass..............	14 6	59 7	7.2	1,2	1,7	1,6	14.0	Boussingault.
" Saxony.....................	11,8	64 4	1,4	2,6	2.5	1,6	15 6	Wunder.
" America.................	10,9	63,4	3,8	1,2	8,3	1,6	10.8	Polson.
" Flanders...	10,7	61.0	9,2	1,0	1,8	1,7	14,6	Peligot.
" Odessa....................	14 3	59.6	6,3	1.5	1.7	1,4	15,2	"
" Tanganrock...........	13,6	57,9	7,9	1,9	2,3	1,6	14,8	"
" Poland....................	21,5	53 4	6,8	1.5	1,7	1,9	13,2	"
" Hungary......	13,4	62,2	5,4	1,1	1,7	1.7	14,5	"
" Egypt......................	20,6	55,4	6,0	1,1	1,8	1,6	14 8	"
RYE.								
From Hessia.........	13 6	50,5	8,9	0,9	10,1	1,8	15.0	Fresenius.
" France.....................	11,6	56,5	10,2	1,9	3,5	2,2	14,1	Payen.
" Saxony	9,1	64,9	0,4	2,3	3,5	1,4	18,3	A. Müller.
" "	9,6	56,7	6,4	2,1	8,5	3,3	16,5	Wolff.
BARLEY.								
	10,5	50,3	5,5	2,0	13,6	3,8	15,7	Wolff.
	13,2	53,7	4,2	2,6	11,5	2,8	12,0	Polson.
From Salzmünde, Prussia...	9,3	60,4	1,2	2,0	9,7	2,4	15,0	Grouven.
OATS.								
	8,8	55,4	2,5	6,4	9,6	2,7	14,6	A. Müller.
	15,7	32,2	......	...	......	4,1	12,9	Krocker.
	10,2	......	......	6,1	10,0	2,7	12,6	Anderson.
BUCKWHEAT.								
Husked, from Vienna.........	2,6	78,9	3,8	0,9	1,0	...	12,7	Bibra.
" " "	3,6	76,7	4,3	1,3	1,3	...	13,7	"
" "	13,1	... ..	... ..	3,9	3,5	2,5	13,0	Boussingault.
Unhusked......	8,5	37,8	.. ...	...	......	2,0	14,2	Horsford & Krocker.
"	9,1	45,0	7,1	0,4	22,0	2,4	14,0	Zenneck.
MAIZE.								
From Saxony...................	8,8	58,0	5,3	9,2	4,9	3,2	10,5	Hellriegel.
" America...	8,8	54,4	2,7	4,6	15,8	1,7	12,0	Polson.
" Galacz....................	9,1	49,5	2,9	4,5	20,4	1,8	11,8	"
" Switzerland	... ..	51,2	6,7	3,8	12,5	...	10,6	Bibra.
RICE.								
From Piemont...................	7,5	... ..	.. ..	0,5	0,9	0,5	14,6	Boussingault.
" Patna.......................	7,2	79,9	1,6	0,1	0,5	0,9	9,8	Polson.
" Piemont....................	7,8	... ..	.. ...	0,2	3,4	0,3	13,7	Péligot.
" East Indies..............	5,9	73,9	2,3	0,9	2,0	...	14,0	Bibra.
MILLET.								
Husked, Hagenau................	20,6	... ..	.. ...	3,0	2.4	2,2	14,0	Boussingault.
" Nuremberg...........	10,3	57,0	11,0	8,0	2,0	...	12,2	Bibra.

TABLE V.

DETAILED ANALYSES OF POTATOES, by Grouven.

(*Agricultur-Chemie, 2te Auf, pp.* 495 & 355.)

	White Potatoes, newly dug. Unmanured.		White Potatoes, newly dug. Manured.		Various Sorts, Average of 19 Analyses.
Water	74,95		78,01		76,00
Albumin	0,47	=2,11	0,89	=3,19	2,80
Cascin	0,04		0,03		
Gliadin & Mucidin [?]	0,29		0,25		
Veg. Fibrin	1,31		2,02		
Gum and pectin	0,76		1,56		1,81
Org. Acids	2,00		1,50		
Fat	0,07		0,05		0,30
Starch	17,33		13,40		15,24
Cellubose	11,90		1,24		1,01
Ash	0,88		1,05		0,95
	100		100.		

TABLE VI.

DETAILED ANALYSES OF SUGAR BEETS.

	Water.	*Albuminoids.*	*Sugar.*	*Org. Acids, pectin, &c.*	*Crude fiber.*	*Ash.*	*Analyst.*
Hohenheim	81,5	0,87	11,90	3,47	1,33	0,89	Wolff.
Moeckern	84,1	0,82	9,10	3,90	1,05	0,99	Ritthausen.
" 2 lbs	81,7	0,84	11,21	3,86	1,36	0,94	"
" ½ lbs	79,5	0,90	12,07	5,09	1,52	0,88	"
Bickendorf, 1½ lbs	70,0	0,70	12,90	5,00	1,20	0,70	Grouven.
Slanstädt, 2 lbs	80,0	0,68	13,37	5,21		0,74	Stockhardt.
Lockwitz, 1¼ lbs	79,9	0,65	13,32	5,53		0,60	"
Tharand, 1½ lbs manured	82,7	0,93	12,34	3,24		0,79	"
" 2 lbs. manured	81,8	1,16	10,15	5,77		1.12	"
" 3¼ lbs. manured	82,1	1,14	9,25	6,36		1.15	"
" 4 lbs. manured	82,5	1,05	8.45	7,07		0,93	"
Silesia, unmanured	84.4	1,14	9,80	3,96		0,69	Bretschneider.
" manured with nitrate of soda	82,7	1,42	11,57	3,63		0,68	"
" man'd with phosphate of lime.	84.1	1,20	9,82	4,04		0,77	"
Average	81,5	0,95	11.5	3,7	1,3	0.85	

TABLE VII—COMPOSITION OF FRUITS, according to FRESENIUS. (*Ann. Ch. u. Ph.*, 101, *p.* 219)

	Soluble Matters						Seeds, Skins and Insoluble Matters.					Water.	
	*Sugar.**	*Free Acid.*†	*Albuminoids.*	*Pectin bodies. Gum, Organic Acids in Combination.*	*Soluble Ash Ingredients.*	*Total Soluble Matters.*	*Seeds.*	*Skins and Cellulose.*	*Pectose.*	*Insoluble Ash Ingredients.*‡	*To'l Insolu- Matters.*		
GOOSEBERRIES.													
1. Large, rid, prickly 1854	8,063	1,358	0,441	0,969	0,317	11,148	2,481	0,512	0,294	(0,146)	3,287	85,565	100,000
2. Small, red, prickly 1854	6,030	1,573	0,445	0,513	0,452	9,013	2 442		0,515	(0.069)	2,957	80,030	100,000
3. " " " 1855	8,239	1,589	0,358	0,522	0,504	11,212	2,529		1,428	(0,247)	3,957	84,831	100,000
							3,380	0,442	0,308	(0,100)	4,130	86,419	100,000
4. Medium yellow, nearly smooth..............1854	6,383	1,078	0,578	2,112	0,200	10,351							
5. " " " " 1855	7,507	1,334	0,369	2,113	0,277	11,600	2,081		0,955	(0,170)	3,036	85,364	100,000
6. Large, red, smooth.........................1855	6,483	1,664	0,306	0,843	0,553	9,849	2,803		0,390	(0,133)	3,193	86,958	100,000
CURRANTS.													
7. Red, medium, ripe..........................1854	4,78	2,31	0,45	0,28	0,54	8,36	4,45	0,66	0,69	(0,11)	5,80	85,84	100,00
8. " " " 1855	6,44	1,84	0,49	0,19	0,57	9,53	4 48		0,72	(0,23)	5,20	85,27	100,00
9. Very large cherry currants..................1855	,647	1,695	0,356	0,007	0,620	8,35	3,940		2,380	(0,185)	6,320	85,355	100,000
10. White....................................1854	56,61	2,26	0,77	0,18	0,54	10,36	4.94		0,53	(0,12)	5,47	84.17	100,00
11. " 1855	7,692	2,258	0,300		0,560	10.810	4,144		0,24		4,384	84,806	100,000
12. " 1856	7,12	2,53	0,68	0,19	0,70	11,22	4,85		0 51	(0,14)	5.36	83,42	100,00
STRAWBERRIES.													
13. Wild.....................................1854	3,247	1,650	0,619	0,145	0,737	6,398	6,032		0,299	(0,315)	6,331	87,271	100,000
14. " 1855	4,550	1,332	0.567	0,049	0 603	7,101	5.580		0,300	(0,345)	5,880	87,019	100,000
15. Ananas...................................1855	7,575	1,133	0,359	0,119	0,480	9,666	1,960		0,900	(0,154)	2 860	87,474	100,000
RASPBERRIES.													
16. Red, wild................................1854	3,597	1,980	0,546	1,107	0,270	7,500	8,460		0,180	(0,134)	8,640	83,860	100,000
17. Red, garden..............................1855	4.708	1,356	0,544	1,746	0,481	8,835	4 106		0,502	(0,296)	4,608	86,557	100,000
18. White, garden............................1855	3,703	1,115	0,665	1,397	0,380	7,260	4,520		0,040	(0,081)	4 560	88,180	100,000

*Saccharose and Fructose. †Expressed as hydrated malic acid. ‡Already included in Seeds, Skins, etc.

COMPOSITION OF FRUITS, according to FRESINIUS. (*Ann. Ch. u. Ph.*, 101 *p* 219.)

		Soluble Matters.						Seeds, Skins and Insoluble Matters.					Water.	
		Sugar. *	*Free Acid.* †	*Albuminoids.*	*Pectin bodies. Gum, Organic Acids in Combination.*	*Soluble Ash Ingredients.*	*Total Soluble Matters.*	*Seeds.*	*Skins and Cellulose.*	*Pectose.*	*Insoluble Ash Ingredients.* ‡	*To'l Insoluble Matters.*		
19.	BLACKBERRIES.	4,444	1,188	0,510	1.444	0,414	8 000	5,210		0,384	(0,074)	5,594	86,406	100,000
20.	WHORTLEBERRIES.	5,780	1,341	0.794	0,555	0,858	9,328	12,864		0,256	(0,550)	13,120	77,552	100,000
21.	MULBERRIES. Black.	9,192	1.860	0.394	2 031	0.566	14,043	0,905		0,345	(0,089)	1,250	84,707	100,000
	GRAPES.													
22.	Austrian white 1854	13.780	1,020	0,832	0,498	0,360	16,490	2,592		0,941	(0,117)	3,533	79,977	100,000
23.	Kleinberger 1855	10,590	0,820	0,662	0,220	0,377	13.629	1,770		0,750	(0,077)	2,520	84,870	100,000
24.	Riessling, Oppenheim 1855	13,52	0,71		4,07		18.30	....		... ...	....	5,66	76,04	100,00
25.	" " 1855	15,14	0,50		3,46		19,10	....		... ...	....	6,52	74,38	100,00
26.	" Johannisberg 1850	19,24	0,66		2,95		22,93	....		... ...	....	....	....	....
27.	Assmanhauser, red 1856	17,28	0,75		... ..		....	....		... ...	....	....	....	... .
	CHERRIES.													
28.	Sweet, pale red 1854	13.110	0,351	0,903	2,286	0,600	17,250	5,480	0,450	1 450	(0,090)	7,380	75,370	100,000
29.	Sweet, white 1855	8,568	0.961		3,529	0,835	13,435	3,244	0 464	0,401	(0,070)	4,109	82,456	100,000
30.	Sweet, black 1855	10,700	0,560	1,010	0,670	0,600	13,540	5,730	0,366	0 664	(0,078)	6,760	79,700	100,000
31.	Sour 1855	8,772	1,277	0,825	1,831	0,565	13,270	5,182	0,808	0,246	(0,067)	6,236	80,494	100,000
	PLUMS.													
32.	Green Gage, common, yellow, *Mirabelle*: 1854	3,584	0.582	0,197	5,772	0,570	10,725	5,780	0,179	1,080	(0,082)	7,039	82,236	100,000
33.	do. med. size, yellowish green, *Reineclaude*. '54	2,960	0,960	0,477	10,475	0,318	15,190	3.250	0,680	0,010	(0,039)	3,940	80,841	100,000
34.	do. large, green, very sweet and juicy " 1855	3,405	0,870	0,401	11,074	0,398	16,148	2,852	1,035	0,245	(0,037)	4,132	79,720	100,000
35.	Blue, medium size, tart 1854	1,099	1,270	0 475	2,313	0 496	6,550	4.190	0,509		(0,041)	4 699	88 751	100.000
36.	Black, fair flavor 1855	2,252	1,331	0,426	5.851	0,553	10,413	3,329	1,020		(0,063)	4,349	85,238	100,000
	PRUNES.													
37.	Com'n moderately sweet, w'ght 16 grms.. '55	5,793	0,952	0 785	3,646	0,734	11,910	3,540	1,990	0,630	(0,094)	6,160	81,930	100,000
38.	Large Italian· very sweet, w'ght 19 grms.. '55	6,730	0,841	0,832	4,105	0,590	13,098	3,124	0,972	1,534	(0,066)	5,630	81,272	100,000

*Saccharose and Fructose. †Expressed as hydrated malic acid ‡Already included in Seeds, Skins, etc.

COMPOSITION OF FRUITS, according to Fresenius. (*Ann. Ch. u. Ph.*, 101, *p.* 219.)

		Soluble Matter.						Seeds, Skins & Insoluble Matters.					Water.	
		*Sugar.**	*Free Acid.*†	*Albuminoids*	*Pectin bodies. Gum, Organic Acids sn Combination.*	*Soluble Ash Ingredients.*	*Total Soluble Matters.*	*Seed.*	*Skins and Cellulose.*	*Pectose.*	*Insoluble Ash Ingredients.*‡	*To'l Insoluble Matters.*		
Apricots.														
39. Handsome, rather large, weight 47 grms...	1854	1,140	0,898	0,832	5,929	0,820	9,619	4,300	0,967	0,148	0,071)	5,415	84,966	100,000
40. Very delicate, large, weight 60 grms.........	1854	1,531	0,766	0,389	9.283	0,754	12,723	3,216	0 944	1,002	(0,104)	5,266	82 011	100,000
Peaches.														
41. Large Holland.........	1855	1,580	0,612	0,463	6,313	0,422	9,390	4,629	0,991		(0,042)	5,620	84,990	100,000
42. " " .. ..,	1855	1,565	0,734		11,058	0,913	14,270	6,764	2,420		(0,163)	9,184	76,546	100,000
Apples.														
43. Large English Reinette.....	1853	9,25	0,53		1,80		11,58	... ...	... ...	... ...	.. ..	2,39	86,03	100,00
44. " " "	1854	5,96	0,39	0,52	7,61	0,22	14,70	0,07	1,71	1,49	(0,06)	3,27	82,03	100.00
45. " " "	1855	6,83	0,85	0,45	6,47	0,36	14,96	1,95		1,05	(0,03)	3,00	82,04	100,00
46. White table apple	1854	7.58	1,04	0,22	2,72	0,44	12,00	0,38	1,42	1,16	(0,03)	2 96	85,04	100,00
47. Borsdorfer...............	1853	7,61	0,61		6,85		15.07	... ...	... ...	... ...	....	2,44	82,49	100,00
48. White, *Matapfel*..................................	1853	8,98	1,01		3,35		13,34	... ...	... ...	... ...	....	4,53	82,13	100,00
49. English Winter Goldpearmain.	1853	10,36	0,48		5,11		15,95	... ...	... ...	... ...	... .	2,18	81,87	100,00
Pears.														
50. Sweet, red pear.........	1854	7.000	0,074	0,260	3,281	0,285	10,900	0,390	3.420	1,340	(0,050)	5,150	83,950	100000
51. " " "	1855	7,940	trace	0,237	4,409	0,284	12,870	3,518		0,605	(0,049)	4,123	83,007	100,000

*Saccharose and Fructose. †Expressed as hydrated malic acid. ‡Already included in Seeds, Skins, etc.

TABLE VIII.

FRUITS ARRANGED IN THE ORDER OF THEIR CONTENT OF SUGAR.
(average) Fresenius.

	per cent.		per cent.
Peaches	1.6	Currants	6,1
Apricots	1,8	Prunes	6,3
Plums	2,1	Gooseberries	7,2
Reineclaudes	3,1	Red pears	7.5
Mirabelles	3,6	Apples	8,4
Raspberries	4,0	Sour cherries	8,8
Blackberries	4 4	Mulberries	9,2
Strawberries	5,7	Sweet cherries	10.8
Whortleberries	5,8	Grapes	14,9

TABLE IX.

FRUITS ARRANGED IN THE ORDER OF THEIR CONTENT OF FREE ACID EXPRESSED AS HYDRATE OF MALIC ACID, (average) Fresenious.

	per cent.		per cent.
Red pears	0 1	Blackberries	1,2
Mirabelles	0,6	Sour cherries	1,3
Sweet cherries	0,6	Plums	1,3
Peaches	0,7	Whortleberries	1,3
Grapes	0,7	Strawberries	1,3
Apples	0,8	Gooseberries	1,5
Prunes	0,9	Raspberries	1.5
Reineclaudes	0,9	Mulberries	1,0
Apricots	1,1	Currants	2,0

TABLE X.

FRUITS ARRANGED ACCORDING TO THE PROPORTIONS BETWEEN ACID, SUGAR, PECTIN, AND GUM, ETÇ., (averages) Fresenius.

	Acid.	*Sugar.*	*Pectin, Gum, etc.*
Plums	1	1,6	3 1
Apricots	1	1,7	6,4
Peaches	1	2,3	11,9
Raspberries	1	2.7	1,0
Currants	1	3 0	0,1
Reineclaudes	1	3.4	11,8
Blackberries	1	3 7	1,2
Whortleberries	1	4.3	0,4
Strawberries	1	4 4	0,1
Gooseberries	1	4 9	0,8
Mulberries	1	4 9	1,1
Mirabelles	1	6,2	9,9
Sour cherries	1	6.9	1,4
Prunes	1	7 0	4,4
Apples	1	11,2	5,6
Sweet cherries	1	17,3	2,8
Grapes	1	20,2	2,0
Red pears	1	94,6	44,4

TABLE XI.

FRUITS ARRANGED ACCORDING TO THE PROPORTIONS BETWEEN WATER, SOLUBLE MATTERS, AND INSOLUBLE MATTERS.

(averages) FRESENIOUS.

	Water.	*Soluble Matter.*	*Insoluble Matter.*
Raspberries	100	9,1	6,9
Blackberries	100	9,3	6.5
Strawberries	100	9.4	5,2
Plums	100	9,7	0,9
Currants	100	11,0	6,6
Whortleberries	100	12,1	16,9
Gooseberries	100	12,2	3,6
Mirabelles	100	13.0	1,5
Apricots	100	13,3	2,1
Red pears	100	14,3	5,5
Peaches	100	14,6	2,1
Prunes	100	15,3	3,2
Sour cherries	100	16,5	1,3
Mulberries	100	16,6	1,5
Apples	100	16,9	3,6
Reineclaudes	100	18,5	1,2
Cherries	100	18,6	1,5
Grapes	100	22,8	5,8

TABLE XII.

PROPORTION OF OIL IN VARIOUS AIR-DRY SEEDS, according to BERJOT.

(*Knop's Agricultur Chemie*, p. 725.)

(The air-dry seeds contain 10-12 per cent of hygroscopic water.)

Colza, common	40–45	Gold of Pleasure	35
" *Schirmraps*	44	Watermelon	36
" red India	40	Charlock	15–42
" white "	40	Orange	40
Flax	34	Colocynth	16
Poppy	40–50	Cherry	42
Sesame	53	Almond	40
Mustard, white	30	Potato	16
" black	29	Buckthorn	16
Hemp	28	Currant	26
Peanut	38	Beechnut	24

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